HRS DOCUMENTATION RECORD COVER SHEET

Name of Site: Fort Detrick Area B Ground Water

EPA ID No.: MDD985397249

Contact Persons

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Pathways, Components, or Threats Not Scored

Surface Water Overland Migration Pathway

The surface water pathway was not scored. The ground water pathway was sufficient to list the site.

Soil Exposure Pathway

The soil exposure pathway was not scored. The ground water pathway was sufficient to list the site.

Air Migration Pathway

The air migration pathway was not scored. The ground water pathway was sufficient to list the site.

HRS DOCUMENTATION RECORD

Name of the Site:	Fort Detrick Area B Ground Water
EPA Region:	3
Street Address of Site*:	810 Schreider Street
City, County, State, Zip:	Fort Detrick, Frederick, Frederick County, Maryland, 21702
General Location in State:	North-central portion of Maryland.
Topographic Map:	Frederick, Maryland
Latitude:	Longitude:
39º26'03.99"	77º26'48.37"

Reference for latitude and longitude: Google Earth (www.earth.google.com) and Reference 42, measured from the southwest corner of the building centrally located in Area B (see Reference 42 for location).

** The street address, coordinates, and contaminant locations presented in this HRS documentation record identify the general area in which the site is located. They represent one or more locations EPA considers to be part of the site based on the screening information EPA used to evaluate the site for NPL listing. EPA lists national priorities among the known "releases or threatened releases" of hazardous substances; thus, the focus is on the release, not precisely delineated boundaries. A site is defined as where a hazardous substance has been "deposited, stored, placed, or otherwise come to be located." Generally, HRS scoring and the subsequent listing of a release merely represent the initial determination that a certain area may need to be addressed under CERCLA. Accordingly, EPA contemplates that the preliminary description of facility boundaries at the time of scoring will be refined as more information is developed as to where the contamination has come to be located.*

Scores

Air Migration Pathway	Not Scored
Ground Water Migration Pathway	99.05
Soil Exposure Pathway	Not Scored
Surface Water Migration Pathway	Not Scored
HRS Site Score	49.52

WORKSHEET FOR COMPUTING HRS SITE SCORE

	S pathway	S^2 pathway
Ground Water Migration Pathway Score (S_{gw})	99.05	9810.9025
Surface Water Migration Pathway Score (S_{sw})		
Soil Exposure Pathway Score (S_s)		
Air Migration Score (S_a)		
$S^2_{gw} + S^2_{sw} + S^2_s + S^2_a$		9810.9025
$(S^2_{gw} + S^2_{sw} + S^2_s + S^2_a)/4$		2452.7256
$\sqrt{(S^2_{gw} + S^2_{sw} + S^2_s + S^2_a)/4}$		49.52

TABLE 3-1 --GROUND WATER MIGRATION PATHWAY SCORESHEET			
Factor categories and factors	Maximum Value	Value Assigned	
Aquifer Evaluated: One Interconnected Aquifer			
Likelihood of Release to an Aquifer:			
1. Observed Release	550	550	
2. Potential to Release:			
2a. Containment	10		
2b. Net Precipitation	10		
2c. Depth to Aquifer	5		
2d. Travel Time	35		
2e. Potential to Release [lines 2a(2b + 2c + 2d)]	500		
3. Likelihood of Release (higher of lines 1 and 2e)	550		550
Waste Characteristics:			
4. Toxicity/Mobility	(a)	10,000	
5. Hazardous Waste Quantity	(a)	100	
6. Waste Characteristics	100		32
Targets:			
7. Nearest Well	(b)	50	
8. Population:			
8a. Level I Concentrations	(b)	217.8	
8b. Level II Concentrations	(b)	0	
8c. Potential Contamination	(b)	186.5	
8d. Population (lines 8a + 8b + 8c)	(b)	404.3	
9. Resources	5	5	
10. Wellhead Protection Area	20	5	
11. Targets (lines 7 + 8d + 9 + 10)	(b)		464.3
Ground Water Migration Score for an Aquifer:			
12. Aquifer Score [(lines 3 x 6 x 11)/82,500][c]	100		99.05
Ground Water Migration Pathway Score:			
13. Pathway Score (S_{gw}), (highest value from line 12 for all aquifers evaluated)[c]	100		99.05

[a] Maximum value applies to waste characteristics category
[b] Maximum value not applicable
[c] Do not round to nearest integer

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SITE SUMMARY - FORT DETRICK AREA B GROUND WATER

The Fort Detrick facility is an active U.S. Army Installation operated under the Army Medical Command (MEDCOM), in Frederick, Maryland. Fort Detrick is located within the city limits of Frederick and is surrounded by residential areas and county-owned land (Ref. 3; Ref. 4, p. I-3).

Fort Detrick consists of three non-contiguous tracts of land designated as Areas A, B, and C. Sources evaluated in this Hazard Ranking System (HRS) documentation record are located in Area B. Area B occupies approximately 399 acres and was used as a disposal area for chemical, biological, and radiological (CBR) material and until 1970 for biological experimentation (Ref. 4, pp. ii, I-3; Ref. 5, p. 1-2).

Area B has been the primary location of waste management activities for Fort Detrick and is the location of an active municipal landfill, animal farm, former skeet range, former explosives storage area, and former waste disposal/test areas associated with former research activities. In the late 1940s, the Special Operations Group of Fort Detrick installed a test grid in Area B to test both live and simulant biological warfare (BW) materials. A list of the live agent materials used in Area B is not available, but it is known that simulant materials used included *Bacillus globigii*, *Serratia marcescens*, and *Escherichia coli*. Test animals were buried in trenches or pits located in Area B after autoclave sterilization. Many types of munitions were tested on the grid in Area B (Ref. 4, pp. iii, II-3; Ref. 5, p. 1-2). A residential community is located within 100 feet of the Area B disposal areas (Ref. 7, p. 2).

Anthrax was buried in Area B. In addition, radiological tracer materials were reportedly buried at three locations in Area B, including radioactive carbon, sulfur, and phosphorous. Two cylinders marked “Phosgene” were also reportedly buried in Area B. Phosgene is considered a lethal chemical agent (Ref. 4, pp. iii, iv). Reference 6 shows the locations of various operational, test, and disposal areas. This reference identifies each area by the letter “B” (for Area B) followed by a number for identification and discussion purposes (Ref. 6).

In 1970 and 1971, after the United States outlawed biological research for offensive operations, a decontamination and certification program was completed at Fort Detrick. Decontamination procedures for residual biological/chemical research materials included autoclave steam sterilization and incineration. Incineration ash was tilled into soil in the northwestern corner of Area B (Pit 13). Research buildings and equipment were also decontaminated, and an extensive wipe sampling program was completed after decontamination. In addition, sewage drainage lines were cut and capped, and drainage systems were filled with hypochlorite solution where possible (Ref. 4, II-3; Ref. 5, p. 2-1).

In 1977, severe soil erosion exposed buried scrap materials and created several deep cavities in Area B. The areas were subsequently covered with soil (Ref. 4, p. V).

In June 2004, a removal action was completed at Area B-11, an Area B chemical disposal area. Activities completed included the removal of contaminated soil, chemical containers, compressed gas cylinders, and laboratory waste. The discovery of live pathogens in medical wastes at Area B-11 caused suspension of all intrusive work at the disposal area (Ref. 5, p. 1-2).

Since 1999, quarterly ground water sampling has been conducted in and south of Area B-11. Ground water sampling activities include monitoring wells and drinking water wells along the southern facility boundary. The volatile organic compounds (VOC) trichloroethene (TCE) and tetrachloroethene (PCE) are the major chemical constituents detected in ground water (Ref. 32, p. 1-1). Data from ground water sampling conducted in 2005 is illustrated in isopleths maps, Exhibits 4-2 and 4-3 of Reference 23. The TCE and PCE isopleth maps illustrate the TCE and PCE plume as extending from the western boundary of Area B to eastern boundary of Area B. However, as indicated on Exhibit 4-2 of Reference 23, TCE also was detected in a residential well located on the southern portion of Shookstown Road. Therefore, the plume may extend to the location of this residential well (Ref. 23, Exhibit 4-2).

TCE and PCE have been detected in drinking water wells. Most of the drinking water wells have been closed, and residents are provided with public water or bottled water (Ref. 32, p. 4-2 and Exhibit 4-1; Ref. 46, pp. 4-21 and 4-22). Fort Detrick provides residents not connected to the public water supply with bottled water (Ref. 24). In 1992, ground water samples collected from six drinking water wells contained concentrations of TCE above the cancer risk screening concentration or at concentrations meeting the criteria for documenting Level I actual contamination. One of these wells contained TCE and PCE concentrations above their respective MCLs; and another contained TCE concentrations above the MCL (Ref. 2, pp. A-1, BII-11; Ref. 25, p. 3; Ref. 51). In September 2005, two ground water samples collected from residential wells contained TCE or PCE at concentrations meeting the criteria for documenting Level I actual contamination (Ref. 2, pp. A-1, BII-11; Ref. 23, p. 4-2 and Exhibit 4-1). A total of eight wells are evaluated as HRS Level I target wells (Ref. 23, p. 4-2 and Exhibits 4-1 and 4-2; Ref. 25; Ref. 51).

2.2 SOURCE CHARACTERIZATION

2.2.1 SOURCE IDENTIFICATION

Name of source: Chemical Waste Disposal Pits - Area B-11
Number of source: 1
Source type: Landfill

Source No. 1, the Chemical Waste Disposal Pits or Area B-11, is located in the southwest portion of Area B of Fort Detrick. Area B-11 encompasses an area measuring approximately 800 by 2,200 feet (Ref. 7, p. 2-1). Detailed historical records of disposal are limited, but Area B-11 is the reported location of several landfills containing demolition and remodeling debris from Area A buildings and several unlined trenches or pits (Ref. 7, Exhibits 1-2 and 2-1; Ref. 29, p. 2-5). At Area B-11, various types of chemicals and acids as well as general household refuse were buried in unlined trenches and pits. Landfill and disposal activities in Area B-11 were terminated in 1970 (Ref. 7, pp. 1-1, 2-1; Ref. 29, p. 2-5).

The southwestern portion of Area B contains three known chemical waste disposal pits (Pits 1, 3, and 4), one suspected chemical waste disposal pit (Pit 2), and one ash disposal pit. Area B-11, also known as Pit 11, is reported to have received various types of waste chemicals from Fort Detrick, the National Bureau of Standards, and the Walter Reed Army Medical Center from 1955 to 1970 (Ref. 7, p. 2-1). Reportedly, eight 55-gallon drums of TCE were disposed of in Pit 1 (Ref. 7, p. 2-4). A 1977 initial assessment report for the Fort Detrick facility describes the pits in Area B, but it is not clear which pits are located in Area B-11. Wastes disposed of in the pits included metals, wood, general waste from laboratory modifications and building demolition, refuse from housing and animal farm operations, acids and chemicals, incinerated medical waste, waste herbicides and insecticides, phosgene, and animals potentially contaminated by anthrax (Ref. 4, pp. II-3, II-4, and II-5; Ref. 29, p. 2-5).

Area B-11 is underlain by solution-weathered limestone of the Frederick Formation, a karst formation aquifer. Solution features such as voids were identified in Area B-11 during the installation of monitoring wells. The voids are 10 to 87 feet long and were encountered with the greatest concentration in the first 100 feet of drilling. Drilling in Area B-11 revealed that bedrock is located at 32 to 33 feet below ground surface (bgs) (Ref. 7, p. 2-1). The nature of karst conditions in Area B-11 increases the probability of releases to ground water from wastes disposed of in Area B-11. Wastes may have been disposed of directly into karst solution cavities (voids) resulting in ground water contamination.

A decision document dated July 14, 2000 authorized Fort Detrick to begin work on the Interim Removal Action (IRA) at Area B-11 (Ref. 29, p. 2-6). The buried wastes were covered with 0 to 3 feet of clean overburden. The removal included the excavation of waste and commingled soils from the pit (Ref. 7, p. 3-3). The removal action was completed in June 2004 with approximately 3,500 tons of waste and commingled soils removed from the source area of TCE and PCE contamination. Numerous drums and bottles were removed along with live, biological material in laboratory glassware. The disposal pits were backfilled with clean fill. The entire area was then covered with several inches of soil and seeded. Following the IRA, soil samples were collected from the bottom of the pit excavations. TCE, PCE, and PCBs were detected in the soil samples (Ref. 29, p. 2-6).

Location of source, with reference to a map of the facility: See Reference 6 for the location of the source in the southwest portion of Area B.

Containment:

Release to ground water: Migration of hazardous substances from the source area is documented; therefore, a containment factor value of 10 is assigned to this source (see Section 3.0 of this HRS documentation record). Additionally, as discussed above, the source does not have a liner or containment system (Ref. 1, Table 3-2; Ref. 7, p. 2-1).

Release via overland migration and/or flood: The overland migration and/or flood migration pathway was not scored.

Gas release to air: The air migration pathway was not scored.

Particulate release to air: The air migration pathway was not scored.

2.4 WASTE CHARACTERISTICS

2.4.1 HAZARDOUS SUBSTANCES – AREA B-11

In 1998, a remedial investigation (RI) was performed in an effort to locate the source of the TCE and PCE in ground water and determine if further degradation of ground water was likely to occur. During the RI, soil borings, test trenches, soil sampling, an electromagnetic geophysical survey, and a soil gas survey were performed in Area B-11. The borings and test trenches revealed the presence of buried chemicals, including laboratory bottles and 55-gallon drums. VOCs, including TCE and PCE, and semivolatile organic compounds (SVOC) were detected in soil samples at concentrations below the U.S. Environmental Protection Agency (EPA) Region III risk-based concentrations (RBC). A subsequent soil gas survey identified VOCs at concentrations exceeding background concentrations (Ref. 7, p. 2-2).

Based on the RI data, Area B-11 Chemical Waste Disposal Pits were identified as the source of Area B ground water contamination (Ref. 7, p. 2-2).

During the 1998 IRA, pit delineation activities were also initiated to determine the amount of wastes disposed of in the pits. The geophysical survey estimated bedrock to occur at 32 to 33 feet bgs. Fifty-nine trenches were excavated to determine the lateral extent of the pits. More than 63 chemical and biological samples were collected from the trenches. Based on trenching results, four chemical waste disposal pits and one ash pit were identified. The total estimated volume of the pits is 2,768 cubic yards (1,833 cubic yards in Pit 1; 83 cubic yards in Pit 2; 250 cubic yards in Pit 3; and 602 cubic yards in Pit 4) (Ref. 30, p. 1-3).

During test trenching, soil samples were collected from the pits. A soil sample from Pit 1 contained Aroclor-1260 at a concentration of 3,820 micrograms per kilogram (µg/kg) (Ref. 7, Appendix B, TCLP and Total PCB Results, p. 1). A soil sample from Pit 3 contained estimated concentrations of Aroclor-1254 at 2,060 µg/kg and Aroclor-1260 at 1,480 µg/kg (Ref. 7, Appendix B, table entitle "TCLP and Total PCB Results Collected During Test Trenching Activities," p. 2). Benzene (at 0.0346 mg/L), chloroform (at 4.12 mg/L), 1,2-DCA (at 0.0153 mg/L), PCE (up to 2.36 mg/L), and TCE (up to 1.31 mg/L) also were detected in the pit soil samples (Ref. 7, Appendix B, table entitled "TCL VOC TAL SVOC and TAL and Metals Results Collected During Test Trenching Activities").

As of November 25, 2002, 1,804 tons of hazardous soil had been removed from the Pit 1 excavation (Ref. 7, p. 2-3). A soil sample from Pit 1 contained carbon tetrachloride at 1,800 µg/kg; TCE at 1,200 µg/kg; toluene at 2,400 µg/kg; PCE at 4,200 µg/kg; ethylbenzene at 2,700 µg/kg; xylene at 18,000 µg/kg; and 1,2,4-trichlorobenzene at 93,000 µg/kg (Ref. 7, Exhibit 2). Soil samples analyzed for VOCs using EPA's Toxicity Characteristic Leaching Procedure did not reveal detectable concentrations of VOCs; however, carbon samples collected from the air filtration and containment unit over the pit excavation revealed the presence of numerous VOCs. Biological wastes and drums were also removed (Ref. 7, p. 2-3, Appendixes A and B). Samples were collected and analyzed in accordance with the August 2001 sampling and analysis plan (Ref. 30).

Biomaterials, including *Bacillus anthracis*, were recovered in jars, vials, and tubes. Cylinders and drums also were recovered (Ref. 7, Appendix A). Numerous biological pathogens were detected in soil samples as summarized in Reference 7, Appendix B, the table entitled "Sentinel Microbiological Results." A pit bottom soil sample contained carbon tetrachloride at 1.8 mg/kg; TCE at 1.2 mg/kg; toluene at 2.4 mg/kg; PCE at 4.2 mg/kg; ethylbenzene at 2.7 mg/kg; xylene at 18 mg/kg; and 1,2,4-trichlorobenzene at 93 mg/kg (Ref. 7, p. 2-4, Appendix B, Table Entitled "Sentinel Chemical Results," p. 8).

The Area B-11 air filter carbon data show that TCE, PCE, carbon tetrachloride, and acetone were captured at the highest concentrations from air. The carbon units captured approximately 22 pounds of VOCs (Ref. 7, p. 2-4, Exhibit 2).

2.4.2.1 Hazardous Waste Quantity

2.4.2.1.1 Hazardous Constituent Quantity

The information available is not sufficient to adequately support evaluation of the hazardous constituent quantity for Source No. 1.

2.4.2.1.2 Hazardous Waste Stream Quantity

The information available is not sufficient to adequately support evaluation of the hazardous waste stream quantity for Source No. 1.

2.4.2.1.3 Volume

The total estimated volume of the pits is 2,768 cubic yards (1,833 cubic yards in Pit 1; 83 cubic yards in Pit 2; 250 cubic yards in Pit 3; and 602 cubic yards in Pit 4) (Ref. 30, p. 1-3). The hazardous waste quantity assigned value for a landfill is 2,768 cubic yards divided by 2,500, or 1.1072 (Ref. 1, Table 2-5 and Section 2.4.2.1.3).

Dimensions of source (cubic yards): 2,768
Volume Assigned Value: 1.1072

2.4.2.1.4 Area

The area measure is assigned a value of 0 because the volume of the source can be determined (Ref. 1, Section 2.4.2.1.3).

Area Assigned Value: 0

2.4.2.1.5 Source Hazardous Waste Quantity Value

The source hazardous waste quantity (HWQ) value for Source No. 1 is assigned a value of 1.1072.

Source HWQ Value: 1.1072

2.2.1 SOURCE IDENTIFICATION

Name of source: Area B-2
Number of source: 2
Source type: Landfill

Area B-2 is a former waste disposal area located in a grassy field in the northeast portion of Area B. From 1949 until 1951, Area B-2 reportedly received metal, wood, and general waste from building demolition and laboratory remodeling. Wastes were reportedly decontaminated prior to disposal. The waste was buried in a pit and covered with soil. Area B-2 was originally identified as part of the 1993 installation action plan (IAP) for Fort Detrick. Exhibit 1-2 of Reference 5 shows the location of Area B-2 as well as other current Area B disposal areas (Ref. 5, p. 1-3).

A 1957 historical map depicts Area B-2 as a rectangle measuring approximately 1.3 acres and receiving metal, wood, general waste, and decontaminated and construction materials from laboratories from 1949 to 1951 (Ref. 5, p. 4-1, Exhibit 4-2).

Area B-2 is also shown in aerial photographs taken between 1952 and 1988. In the 1952 photograph, Area B-2 is active. A large area of disturbed ground (DG-2), ground scarring (GS-2), and mounded material (MM-2) is evident. The 1958 photograph shows that DG-2 expanded to the north. The 1973 photograph shows a new disturbed ground area (DG-19) north of Area B-2. The disturbed ground also appears in the 1979 and 1988 photographs (Ref. 5, p. 4-1).

Location of the source, with reference to a map of the facility: See Reference 6 for the location of the source in the northeast portion of Area B.

Containment:

Release to ground water: Area B-2 is not lined (Ref. 5, pp. 1-3, 4-1; Ref. 4, p. II-3); therefore, a containment factor value of 10 is assigned to Source No. 2 (Ref. 1, Table 3-2).

Release via overland migration and/or flood: The overland migration and/or flood migration pathway was not scored.

Gas release to air: The air migration pathway was not scored.

Particulate release to air: The air migration pathway was not scored.

2.4 WASTE CHARACTERIZATION

2.4.1 HAZARDOUS SUBSTANCES – AREA B-2

In 1995, the U.S. Army Environmental Center's (USAEC) environmental consultant conducted an initial RI in Area B-2. The purpose of the investigation was to characterize the nature and extent of waste materials, evaluate risks associated with the waste, and to evaluate potential remedial options (Ref. 5, p. l-1). A total of 22 soil borings were completed in selected target areas that showed anomalies during a previously conducted electromagnetic survey. The borings were advanced to 12 feet bgs or auger refusal. In most cases, one surface soil sample (from 0 to 2 feet bgs), one waste sample, and one sample from below the waste were collected from each boring (Ref. 5, pp. 2-1, 4-2). Waste identified in the borings included hard black material and glass (Ref. 5, p. 4-2).

The soil samples collected during the 1995 RI were analyzed on site for Target Compound List (TCL) VOCs, TCL SVOCs, TCL pesticides and polychlorinated biphenyls (PCB), and x-ray fluorescence (XRF) metals (Ref. 5, p. 2-1). The XRF metals included antimony, arsenic, barium, cadmium, calcium, chromium, cobalt, copper, iron, lead, manganese, mercury, potassium, silver, selenium, thallium vanadium, and zinc (Ref. 5, Appendix C, Phase I Soil Data, p. 1 of 83). Fifteen percent of samples were sent to an off-site analytical laboratory for confirmatory analysis and were analyzed for the same parameters plus the complete Target Analyte List (TAL) metals and cyanide. (Ref. 5, p. 2-1).

The Table 1 summarizes the hazardous substances detected in the soil and waste samples. The soil samples were compared to the background concentrations listed in column 2 of Exhibit 4-12 of Reference 5. The background values listed in Exhibit 4-12 are mean background values. The 95% upper confidence limit (UCL) of the mean was selected for comparison to soil sample concentrations. The 95% UCL is an upper bound approximation of the mean (with 95% confidence, the true mean would not exceed this value). The background and the source soil samples were collected from the Tiassic Shale soil type (Ref. 5, p. 4-3 and Exhibit 3-8 and 4-8). The concentrations detected in the soil samples listed in Table 1 are three times the mean background values and above the detection limit.

TABLE 1
AREA B-2 SOIL AND WASTE SAMPLE ANALYTICAL RESULTS

Sample Identification No.	Hazardous Substance	Conc. (mg/kg)	Sample Description	Reference
BORE2B11-A (0-2 feet bgs)	Aroclor-1254	1.29 mg/kg	Silt	5, Exhibit 4-10, p. 2; Appendix A, p. 11, and Appendix C, Phase I Soil Data, p. 6

Sample Identification No.	Hazardous Substance	Conc. (mg/kg)	Sample Description	Reference
BORE2B12-B (10-12 feet bgs)	Beryllium	3.2 mg/kg	Silt	5, Exhibit 4-12, p. 3; Appendix A, p. 12; and Appendix C, Phase I Soil Data, p. 12
BORE2B5-C (10-12 feet bgs)	Chromium	70.7 mg/kg	Silt	5, Exhibit 4-12, p. 2; Appendix A, p. 5; and Appendix C, Phase I Soil Data, p. 67
BORE2B12-B (10-12 feet bgs)	Cobalt	53.1 mg/kg	Silt	5, Exhibit 4-12, p. 3; Appendix A, p. 12; and Appendix C, Phase I Soil Data, p. 12
BORE2B6-A (waste at 0-1.7 feet bgs)	Fluoranthene	20,000 µg/kg	Silt – waste	5, Exhibit 4-10, p.1 and p. 4-2; Appendix A, p. 6; and Appendix C, Phase I Soil Data, p. 69
BORE2B6-A (waste at 0-1.7 feet bgs)	Phenanthrene	10,000 µg/kg	Silt – waste	5, Exhibit 4-10, p. 1, and p. 4-2; Appendix A, p. 6; and Appendix C, Phase I Soil Data, p. 70
BORE2B6-A (waste at 0-1.7 feet bgs)	Pyrene	10,000 µg/kg	Silt – waste	5, Exhibit 4-10, p. 1, and p. 4-2; Appendix A, p. 6; and Appendix C, Phase I Soil Data, p. 69
BORE2B3-C (6-8 feet bgs)	Manganese	3,800 mg/kg	Silt	5, Exhibit 4-12, p. 1; Appendix A, p. 3; and Appendix C, Phase I Soil Data, p. 56
BORE2B12-B (10-12 feet bgs)	Manganese	6,400 mg/kg	Silt	5, Exhibit 4-12, p. 3; Appendix A, p. 12; and Appendix C, Phase I Soil Data, p. 12
BORE2B21-B (4-5.7 feet bgs)	Manganese	3,500 mg/kg	Silt	5, Exhibit 4-12, p. 4; Appendix A, p. 21; and Appendix C, Phase I Soil Data, p. 46
BORE2B3-C (6-8 feet bgs)	Thallium	3.68 mg/kg	Silt	5, Exhibit 4-12, p. 1; Appendix A, p. 3; and Appendix C, Phase I Soil Data, p. 56

Sample Identification No.	Hazardous Substance	Conc. (mg/kg)	Sample Description	Reference
BORE2B5-C (10-12 feet bgs)	Thallium	2.29 mg/kg	Silt	5, Exhibit 4-12, p. 2; Appendix A, p. 5; and Appendix C, Phase I Soil Data, p. 67
BORE2B12-B (10-12 feet bgs)	Thallium	10 mg/kg	Silt	5, Exhibit 4-12, p. 3; Appendix A, p. 12; and Appendix C, Phase I Soil Data, p. 12

Notes:
bgs = Below ground surface
mg/kg = Milligrams per kilogram
µg/kg = Micrograms per kilogram

2.4.2.1 Hazardous Waste Quantity

2.4.2.1.1 Hazardous Constituent Quantity

The information available is not sufficient to adequately support evaluation of the hazardous constituent quantity for Source No. 2.

2.4.2.1.2 Hazardous Waste Stream Quantity

The information available is not sufficient to adequately support evaluation of the hazardous waste stream quantity for Source No. 2.

2.4.2.1.3 Volume

The information available is not sufficient to adequately support evaluation of the volume for Source No. 2.

2.4.2.1.4 Area

A 1957 historical map depicts Area B-2 as a rectangle measuring approximately 1.3 acres or 56,628 square feet (43,560 square feet per acre times 1.3 acres = 56,628 square feet) (Ref. 5, p. 4-1, and Exhibit 4-2). The area assigned value for Source No. 2 is 56,628 divided by 3,400 (source type landfill) = 16.6553. (Ref. 1, Table 2-5).

Area of Source (square feet): 56,628
Area Assigned Value: 16.6553

2.4.2.1.5 Source Hazardous Waste Quantity Value

The source area HWQ value for Source No. 2 is assigned a value of 16.6553 based on the estimated area of the source (Ref. 1, Table 2-6).

Source HWQ Value: 16.6553

2.2.1 SOURCE IDENTIFICATION

Name of source: Area B-Grid
Number of source: 3
Source type: Contaminated soil

The Area B-Grid is a circular area located in the center of Area B previously used as a test grid in the late 1940s to observe the dissemination of biological simulants that were either air-dropped or dispersed as aerosols by detonation using compressed gas or small explosive charges. The biological simulants included *Serratia marcesens* and *Bacillus globigii*, which are nonpathogenic microorganisms. Metal residues from explosive containers and casings are the main source of concern for surface and subsurface soil in the area (Ref. 8, p. 4-1).

Area B-Grid was laid out as a series of seven concentric circles with measurement devices 50 to 1,000 feet from the center. The relic outline of the grid is still discernible. The area is currently used as open land and for an animal farm (Ref. 8, p. 4-1).

Location of the source, with reference to a map of the facility: See Reference 6 for the location of the source in the central portion of Area B.

Containment:

Release to ground water: The Area B-Grid is not lined (Ref. 8, p. 4-1); therefore, a containment factor value of 10 is assigned to Source No. 3 (Ref. 1, Table 3-2).

Release via overland migration and/or flood: The overland migration and/or flood migration pathway was not scored.

Gas release to air: The air migration pathway was not scored.

Particulate release to air: The air migration pathway was not scored.

2.4 WASTE CHARACTERISTICS

2.4.1 HAZARDOUS SUBSTANCES – AREA B-GRID

In 1995, a Phase I investigation was conducted in the Area B-Grid (Ref. 8, p. 4-1). During the investigation, a sampling grid was established with 50-foot spacing. Using a random number generator, 250 grid nodes were selected as sampling points. Two samples were collected from each location from 0 to 0.5 and 0.5 to 1.5 feet bgs. Samples were analyzed in the field using an XRF instrument for metals, with 15 percent of the samples submitted to a laboratory for analysis of TAL metals, mercury, and cyanide (Ref. 8, p. 4-2).

Based on a comparison of the laboratory data to alluvial surface soil background concentrations, numerous metals were detected at concentrations exceeding three times the background concentrations or above the detection limit if not detected in the background sample, as summarized in Table 2 (Ref. 8, p. 4-1 and 4-2). The background concentrations are listed in column 4 of Exhibit 4-9 of Reference 8. The soil sampling locations are listed in Exhibits 4-5 through 4-8. No soil samples descriptions are provided in Reference 8. A summary of the soil samples describe the samples as soil (Ref. 8, Exhibit 4-12).

TABLE 2
AREA B-GRID SOIL SAMPLE ANALYTICAL RESULTS

Sample Identification No.	Hazardous Substance	Concentration (mg/kg)	Reference
HAGRD3-A (0-0.5 feet bgs)	Cadmium	0.286	8, Exhibit 4-9, p. 2
HAGRD4-A (0-0.5 feet bgs)	Cadmium	0.342	8, Exhibit 4-9, p. 2
HAGRD4-B (0.5-1.5 feet bgs)	Cadmium	0.401	8, Exhibit 4-9, p. 2
HAGRD5-A (0-0.5 feet bgs)	Cadmium	0.429	8, Exhibit 4-9, p. 2
HAGRD6-A (0-0.5 feet bgs)	Cadmium	0.323	8, Exhibit 4-9, p. 3
HGRD21-A (0-0.5 feet bgs)	Cadmium	0.453	8, Exhibit 4-9, p. 3
HAGRD21-B (0.5-1.5 feet bgs)	Cadmium	0.421	8, Exhibit 4-9, p. 3
HAGRD22-A (0-0.5 feet bgs)	Cadmium	0.418	8, Exhibit 4-9, p. 3
HADGRD214-B (0.5-1.5 feet bgs)	Cadmium	0.383	8, Exhibit 4-9, p. 13
HAGRD179-b (0.5-1.5 feet bgs)	Chromium	217	8, Exhibit 4-9, p. 12

Sample Identification No.	Hazardous Substance	Concentration (mg/kg)	Reference
HAGRD214-A (0-0.5 feet bgs)	Chromium	74.5	8, Exhibit 4-9, p. 12
HAGRD216-A (0-0.5 feet bgs)	Chromium	84.8	8, Exhibit 4-9, p. 13
HAGRD21-B (0.5-1.5 feet bgs)	Magnesium	14,700	8, Exhibit 4-9, p. 3
HAGRD81-A (0-0.5 feet bgs)	Mercury	0.259	8, Exhibit 4-9, p. 7
HAGRD214-B (0.5-1.5 feet bgs)	Mercury	0.125	8, Exhibit 4-9, p.13
HAGRD220-a (0-0.5 feet bgs)	Mercury	0.176	8, Exhibit 4-9, p. 15
HGRD179-B (0.5-1.5 feet bgs)	Nickel	101	8, Exhibit 4-9, p. 12
HAGRD1-B (0-1.5 feet bgs)	Thallium	3.21	8, Exhibit 4-9, p. 1
HAGRD2-B (0-1.5 feet bgs)	Thallium	2.94	8, Exhibit 4-9, p. 1
HAGRD21-B (0.5-1.5 feet bgs)	Thallium	1.46	8, Exhibit 4-9, p. 3
HAGRD22-A (0-0.5 feet bgs)	Thallium	1.25	8, Exhibit 4-9, p. 3
HAGRD23-B-A (0.5-1.5 feet bgs)	Thallium	1.23	8, Exhibit 4-9, p. 4
HAGRD102D-A (0-0.5 feet bgs)	Thallium	1.4	8, Exhibit 4-9, p. 8
HAGRD130-A (0-0.5 feet bgs)	Thallium	1.27	8, Exhibit 4-9, p. 10

Notes:
mg/kg = Milligrams per kilogram

2.4.2.1 Hazardous Waste Quantity

2.4.2.1.1 <u>Hazardous Constituent Quantity</u>

The information available is not sufficient to adequately support evaluation of the hazardous constituent quantity for Source No. 3.

2.4.2.1.2 <u>Hazardous Waste Stream Quantity</u>

The information available is not sufficient to adequately support evaluation of the hazardous waste stream quantity for Source No. 3.

2.4.2.1.3 <u>Volume</u>

The information available is not sufficient to adequately support evaluation of the volume for Source No. 3.

2.4.2.1.4 <u>Area</u>

As documented in Section 2.4 above, soil samples collected from Source No. 3 revealed the presence of contaminated soil; however, a limited number of soil samples were analyzed for metals by an off-site analytical laboratory. Most soil samples were field screened using an XRF instrument. An area of contaminated soil is difficult to document based on the available laboratory analytical data (Ref. 8, p. 4-2); therefore, the area of soil contamination associated with Source No. 3 is undetermined but greater than zero and is assigned a HWQ value of > 0 (Ref. 1, Table 2-5).

Area of Source (square feet): > 0
Area Assigned Value: > 0

2.4.2.1.5 <u>Source Hazardous Waste Quantity Value</u>

The source area HWQ value for Source No. 3 is assigned a value of >0 (Ref. 1, Table 2-6).

Source HWQ Value: >0

2.2.1 SOURCE IDENTIFICATION

Name of source: Area B-20 South
Number of source: 4
Source type: Contaminated soil

Area B-20 South consists of an approximately 10-foot-high, horseshoe-shaped, earthen berm that ranges in elevation from approximately 370 to 380 feet above sea level. The berm is covered with trees, and the area inside the berm is grass-covered. The berm likely consists of a mixture of locally derived soil. Area B-20 South was used as a control burn area for destruction of explosives located in the western portion of Area B within Area B-Skeet. According to historical records, small quantities of explosive materials were placed in cardboard boxes and burned in the area surrounded by the earthen berm. Residue from the burned material may have affected the local soil (Ref. 8, p. 6-1).

A 1952 aerial photograph of Area B-20 South shows no activity. The 1958 aerial photograph shows a new area of disturbed ground (DG9) and an area of mounded revetment. In 1964, the disturbed ground area (DG9) is no longer visible. A large area of disturbed ground (DG12) encompasses the mounded revetment observed in the 1958 photograph. DG12 is still apparent in the 1970 aerial photograph (Ref. 8, p. 6-1).

Location of the source, with reference to a map of the facility: See Reference 6 for the location of the source in the southwestern portion of Area B.

Containment:

Release to ground water: Area B-20 South is not lined (Ref. 8, p. 6-1); therefore, a containment factor value of 10 is assigned to Source No. 4 (Ref. 1, Table 3-2).

Release via overland migration and/or flood: The overland and/or flood migration pathway was not scored.

Gas release to air: The air migration pathway was not scored.

Particulate release to air: The air migration pathway was not scored.

2.4 WASTE CHARACTERISTICS

2.4.1 HAZARDOUS SUBSTANCES – AREA B-20 SOUTH

During the Phase I investigation conducted in 1995, a sampling grid was established at Area B-20 South using a 5-foot spacing between grid nodes. Fifteen sampling points were selected using a random number generator. Two soil samples were collected from each location at 0 to 0.5 and 0.5 to 1.5 feet bgs. All samples were screened for cyclotrimethylenetrinitramine (RDX) using the USAEC colorimetric method and sent to the on-site laboratory for TCL SVOCs and metals analysis using an XRF instrument. Splits of 17 percent of the samples were submitted to an off-site analytical laboratory for confirmatory analysis of the same parameters, the complete TAL metals list, cyanide, and explosives. No explosives, VOC, or SVOC concentrations exceeded three times the background concentrations (Ref. 8, pp. 6-1 and 6-2). Metals detected at concentrations exceeding three times the background concentration are summarized in Table 3. The background concentrations are provided in column 4 of Exhibit 6-6 and represent the background 95% UCLs for alluvial soil (Ref. 8, p. 6-1). No soil samples descriptions are provided in Reference 8. A summary of the soil samples describe the samples as soil (Ref. 8, Exhibit 6-10).

TABLE 3
AREA B-20 SOUTH SOIL ANALYTICAL RESULTS

Sample Identification No.	Hazardous Substance	Concentration (mg/kg)	Reference
HAB20S3-B	Cadmium	0.543	8, Exhibit 6-6, p. 1
RISB23A	Cadmium	2.7	8, Exhibit 6-6, p. 3
RISB23AD	Cadmium	2.74	8, Exhibit 6-6, p. 3
RISB24A	Cadmium	8.57	8, Exhibit 6-6, p. 3
HAB20S3-B	Cobalt	239	8, Exhibit 6-6, p. 1
RISB23A	Copper	75.7	8, Exhibit 6-6, p. 3
RISB23AD	Copper	92.9	8, Exhibit 6-6, p. 3
RISB24A	Copper	230	8, Exhibit 6-6, p. 3
HAB20S3-B	Manganese	14,000	8, Exhibit 6-6, p. 1
HAB20S3-B	Mercury	0.154	8, Exhibit 6-6, p. 1
RISB23A	Mercury	0.288	8, Exhibit 6-6, p. 3
RISB23AD	Mercury	0.267	8, Exhibit 6-6, p. 3
RISB24A	Mercury	0.756	8, Exhibit 6-6, p. 3
HAB20S3-B	Nickel	269	8, Exhibit 6-6, p. 1
HAB20S3-B	Zinc	251	8, Exhibit 6-6, p. 1
RISB23A	Zinc	723	8, Exhibit 6-6, p. 3
RISB23AD	Zinc	749	8, Exhibit 6-6, p. 3
RISB24A	Zinc	1,380	8, Exhibit 6-6, p. 3

Notes: mg/kg = Milligrams per kilogram

During the 1998 Phase II investigation, two soil borings were completed in the main burn area within the berm in Area B-20 South. Three soil samples were collected from each boring and analyzed for TCL, VOCs, SVOCs, explosives, TAL metals, and cyanide. No debris or disposal material was identified in any sample collected from Area B-20 South. Mercury was detected at thee times the background concentration in soil sample RISB23B at 0.15 mg/kg (Ref. 8, p. 6-2, and Exhibit 6-8).

2.4.2.1 Hazardous Waste Quantity

2.4.2.1.1 <u>Hazardous Constituent Quantity</u>

The information available is not sufficient to adequately support evaluation of the hazardous constituent quantity for Source No. 4.

2.4.2.1.2 <u>Hazardous Waste Stream Quantity</u>

The information available is not sufficient to adequately support evaluation of the hazardous waste stream quantity for Source No. 4.

2.4.2.1.3 <u>Volume</u>

The information available is not sufficient to adequately support evaluation of the volume for Source No. 4.

2.4.2.1.4 <u>Area</u>

As documented in Section 2.4 above, soil samples collected from Source No. 4 revealed the presence of contaminated soil; however, a limited number of soil samples were analyzed for metals by an off-site analytical laboratory. Most soil samples were screened using an XRF instrument. An area of contaminated soil is difficult to document based on the available laboratory analytical data (Ref. 8, p. 6-2); therefore, the area of soil contamination associated with Source No. 4 is undetermined but greater than zero and was assigned a HWQ value of >0 (Ref. 1, Table 2-5).

Area of Source (square feet): > 0
Area Assigned Value: >0

2.4.2.1.5 <u>Source Hazardous Waste Quantity Value</u>

The source area HWQ value for Source No. 4 is assigned a value of > 0 (Ref. 1, Table 2-6).

Source HWQ Value: >0

OTHER POSSIBLE SOURCE AREAS

A site is defined as an area where a hazardous substance has been "deposited, stored, placed, or has otherwise come to be located." A "site" may include multiple sources and may also include areas between sources (Ref. 1, p. 51587). Generally, HRS scoring and the subsequent listing of a release represent the initial determination that a certain area may need to be addressed under the Comprehensive, Environmental Response, Compensation, and Liability Act (CERCLA). The HRS does not require an accurate determination of the full nature and extent of contamination at sites such as would be required during a Remedial Investigation (Ref. 1, p. 51532). As such, many of the possible sources of contamination at a site may not be adequately determined prior to listing on the NPL.

Table 4 summarizes other possible sources of hazardous substances in Area B of the Fort Detrick facility that were not evaluated as part of this HRS documentation record. These sources were not evaluated because the sources have not been adequately characterized or because sufficient data is not available.

In addition to the possible sources summarized in Table 4 below, 21 waste pits have been identified in Area B for the disposal of chemical, biological, and radiological wastes (Ref. 4, pp. II-3 through II-5). The pits are shown on, page II-20 of Reference 4, an Army Installation Assessment of Fort Detrick, Maryland, Record Evaluation Report No. 106, Volume I. A comparison of Reference 4, page II-20 and Reference 6, indicates that some of the pits are within the area of Source 1 (B-11).

TABLE 4
OTHER POSSIBLE SOURCES

Possible Sources	**Location**	**Evidence of Hazardous Substances**	**References**
Area B Ammunition Areas	Eastern portion of Area B	Explosives storage (black powder, rocket motors, and trinitrotoluene "bursters") and munitions loading. Estimated concentrations of 2,4-dinitrotoluene (up to 0.338 milligrams per kilogram [mg/kg]); 2,6-dinitritoluene (up to 0.595 mg/kg); 4-amino-2,6-dinitrotoluene (up to 3.8 mg/kg) and nitrobenzene (up to 0.044 mg/kg) were detected soil samples collected from Area B Ammunition.	6; 8, Exhibit 1-2, p. 3-1, Exhibit 3-11, p. 3-2, pp. 3-13, 3-17, and 3-23; 47, pp. 4-49, 4-50
Area B-1	Eastern portion of Area B	A landfill used for the disposal of metals, wood, and general refuse and laboratory remodeling and building demolition materials. Metals above background concentrations were detected in soil samples.	47, pp. 4-47, 4-48
Area B-3	Northern portion of Area B	Seven to eight landfills also known as an operating landfill (B-3 active) and a group of inactive disposal area (B-3 inactive). Wastes included decontaminated laboratory remodeling and building demolition material, herbicide and insecticide waste, decontaminated drums, metal, general debris, and animal carcasses. Soil samples collected from the Area B-3 inactive contained 1,1,2,2-tetrachloroethane, pesticides, and Aroclor-1260. Ground water samples collected from wells downgradient of the active landfill contained 1,1-dichloroethane, 1,1-dichloroethylene, *cis*-1,2-dichloroethylene, tetrachloroethylene, and vinyl chloride. Leachate from the sanitary landfill contains acetone, 1,1-dichloroethane, methyl ethyl ketone, 4-methyl-2-pentanone, 1,1,1-trichloroethane, and pentachlorophenol.	6; 47, pp. 4-54, 4-55; 55, p. 4, Tables 5-2 and 5-4; 56, p. 7 and Table 5-2
Area B-6	Southwestern portion of Area B	A landfill that received metal, wood, general debris from laboratory remodeling and building demolition, and autoclaved carcasses of animals ranging from mice to horses. Animals used in special operations, involving live biological agents were routinely incinerated before burial. Some carcasses may not have been incinerated prior to disposal, but all were reportedly autoclaved prior to leaving the laboratory. Metals above background concentrations, volatile organic compounds, explosives, and Aroclors 1254 and 1260 were detected in soil samples.	6; 47, pp. 4-60, 4-61, 4-62 and Figure 4-121

Possible Sources	Location	Evidence of Hazardous Substances	References
Area B-8	Western portion of Area B	Wastes included metals, wood, general debris from laboratory remodeling and building demolition, household refuse, and autoclaved carcasses of animals ranging from mice to horses. Animals used in special operations, involving live biological agents were routinely incinerated before burial. Some carcasses may not have been incinerated prior to disposal, but all were reportedly autoclaved prior to leaving the laboratory. Area B-8 received 150 tons of liquid waste and decontamination plant sludge. The sludge contained viable anthrax spores and was mixed with hypochlorite to kill the anthrax prior to its disposal. Area B-8 also reportedly received radioactive carbon, sulfur, and phosphorus compounds. Metals above background concentrations and volatile organic compounds were detected in soil samples.	6; 47, pp. 4-66, 4-67
Trenches north of Area B-8	Western portion of Area B	Depressions thought to represent abandoned burial trenches. Metals above background concentrations and volatile organic compounds were detected in soil samples.	6; 47, pp. 4-63, 4-64
Area B-10	Western portion of Area B	Waste included general housing area refuse and autoclaved and incinerated animal carcasses. Metals above background concentrations and volatile organic compounds were detected in soil samples.	6; 47, pp. 4-69, 4-70
Area B-18	Western portion of Area B	A landfill that received all types of waste. Historical documents mention no other description of the types of waste that were disposed in Area B-18. Inorganics aluminum, barium, beryllium, copper, cyanide, iron, lead, manganese, mercury, nickel, potassium, vanadium, and zinc were detected in Area B-18 soil at concentrations exceeding background levels. Semi-volatile organic compounds, pesticides, and polychlorinated biphenyls were detected in soil samples. Metals also were detected at concentrations above background.	6; 47, pp. 4-56, 4-57
Area B-20 North	Northern portion of Area B	A controlled burn area in excavated pits for destruction of explosives; also used as a firing range. Surface soil sample HAB20N10-A (from 0 to 0.5 foot bgs) revealed cadmium (0.267 mg/kg) and thallium (1.73 mg/kg) concentrations exceeded three times the background concentrations.	6; 8, pp. 5-1, 5-2, and Exhibits 5-8 and 5-9

3.0 GROUND WATER MIGRATION PATHWAY

3.0.1 GENERAL CONSIDERATIONS

<u>Ground Water Migration Pathway Description</u>

Regional Geology

Area B is located in the Western Lowlands Section of the Piedmont Physiographic Province and is characterized by gently sloping hills. The Catoctin Mountain is located approximately 1 mile west of Area B and creates a boundary between the Blue Ridge Physiographic Province (located west of the Catoctin Mountain) and the Piedmont Physiographic Province. The Catoctin Mountain trends southwest to northeast and is part of an overturned anticline known as the South Mountain Anticlinorium. Rocks of the South Mountain Anticlinorium are the oldest in the area and consist of Precambrian gneiss, phylite, and metabasalt (Ref. 9, pp. 3, 4, 7, 10, and plate 1;). The Piedmont Province and Appalachian Blue Ridge Province are separated by a Triassic border fault. Down-faulting along this border fault created a basin in which the Triassic sediments were deposited. Triassic sediments consist of conglomerates, sandstones, siltstones, and shales. After deposition of the Triassic sediments, igneous activity resulted in a diabase intrusion within the basin (Ref. 8, p. 1-5; Ref. 11, plate 1).

East of Catoctin Mountain, where Area B of Fort Detrick is located, is the syncline commonly referred to as the Frederick Valley, which makes up the western portion of the Piedmont Physiographic Province. Rocks of the Frederick Valley consist of Cambrian/Ordovician carbonates and the Frederick and Gove Limestone (Ref. 11, pp. 3, and plate 1). Triassis age rocks underline about two-thirds of the area of the Frederick Valley (Ref. 10, p. 3). Frederick Valley is a highly folded overturned syncline that exposes easily soluble carbonate rocks that range in age from Early Cambrian to Early Ordovician (Ref. 11, p. 1). Area B and the Town of Frederick are located on the Frederick and Gove Limestone of this synclinal unit (Ref. 9, pp. 3, 4, 7, 10, and plate 1; Ref. 11, pp. 3, 4, 5, 6,).

The Frederick Valley is bordered to the east by the Martic Line, which is the surface trace of a thrust fault along where metasedimentary and metavolcanic rocks east of the Frederick Valley were thrust westward onto the carbonates. A portion of these metamorphic rocks and the Martic Line are covered by Triassic sediments (Ref. 9, pp. 3, 4, 7, 10, and plate 1; Ref. 10, pp. 6 and 7).

The dip of Triassic rocks in Carroll and Frederick Counties averages about 20 degrees in the northwest but ranges from 5 to 40 degrees. The strike is generally northeast. There are three prominent joint sets in the Triassic rocks of the Frederick Valley: strike joints that parallel the strike and are nearly vertical (the most prominent joint set); a joint set that strikes North 45 degrees West to North 60 degrees West and that dips steeply to the east (less prominent than the strike joints); and a joint set that strikes east-west (least prominent). These three joint sets are related and are thought have been caused by shearing. A fourth set of obscure joints trend north-south and parallel the Triassic diabase intrusions (Ref. 10, pp. 7 and 8).

Regional Stratigraphy

The consolidated rock units present in the study area are intensely folded and faulted, and the stratigraphic relations are not well understood (Ref. 9, plate 1; Ref. 11, pp. 1, 3). This section presents a discussion of formation distribution and age to provide documentation of the relationships between the numerous formations and aquifers within 4 miles of sources at Area B. The formations within 4 miles of the Fort Detrick facility sources are discussed below in descending order from youngest to oldest.

The Triassic New Oxford Formation consists of thickly interbedded, dark reddish brown, trough cross-bedded, micaceous, medium- to coarse-grained sandstone; red to reddish brown, platy, sandy siltstone; and red-brown, rooted, silty mudstone. The sandstone bases exhibit shale-pebble or quartz-pebble conglomerates at the base. The thickness of the New Oxford Formation is estimated to be 10,000 feet (Ref. 11, p. 36, and plate 1). The New Oxford Formation outcrops in the northeast portion of Area B and consists of conglomerate, shale, sandstone, and siltstone units deposited by streams discharging into down-faulted basins from nearby uplands (Ref. 8, p. 1-4; Ref. 35, pp. 84, 85).

Stratigraphically underlying the Triassic New Oxford Formation is the Ordovician Grove Formation, which includes three members. The lowest member, the Ceresville Member, consists of light gray, sandy dolomite. The middle member, the Fountain Rock Member, consists of thickly interbedded, algal limestones (known as thrombolites) and tan dolomite. The upper member, the Woodsboro Member, is only recognized in the Woodsboro and Walkersville areas and consists of dark gray, thick-bedded, lime mudstone. The thickness of the Grove Formation ranges from 300 to 2,000 feet (Ref. 11, p. 22, plate 1; Ref. 35, pp. 47, 48, 49, 50, 51).

Stratigraphically underlying the Ordovician Grove Formation is the Cambrian Frederick Limestone. This formation consists of thin- to medium-bedded limestone and dolomite with thin intervals of shale and sandstone. The formation includes four members in descending order from youngest to oldest: the Lime Kiln, Adamstown, Rocky Springs Station, and Monocacy Members. The Lime Kiln Member is approximately 600 ft thick and consists of interbedded, thinly laminated to thinly bedded, dark gray, fine-grained limestone, calcareous shale, and medium-bedded, fine-grained limestone near the base, becoming more thickly interbedded toward the top with medium dark gray, fine-grained limestone with wavy bedding and locally stromatolitic algal beds. The Adamstown Member is approximately 1000 feet thick and includes thinly interbedded, medium dark gray to dark gray, argillaceous, fine-grained limestone and dusky yellow to medium dark gray, silty dolomite. The Rocky Springs Station Member consists of interbedded dark gray, thinly bedded, lime mudstone and black dolomitic shale, massive, medium gray, polymictic breccias, medium gray, sandy limestone, and dark gray flaggy lime mudstone. It s approximately 1,200 feet thick on the eastern flank but is likely much thicker on the western flank. The Monocacy Member is predominately black, shaley, lime mudstone with thick intervals of black platy shale at the base and top approximately 400 feet thick (Ref. 11, pp. 7, 11, plate 1; Ref. 35, pp. 43, 44).

The Rocky Springs Station Member outcrops in the southern portion of Area B. Solution cavities were frequently encountered in the Frederick Limestone Formation in Area B at depths ranging from 10 to 186 feet bgs. The solution cavities encountered in this area usually occurred in series of voids and ledges up to 87 feet long (Ref. 8, p. 1-4; Ref. 35, pp. 43, 44, 45).

Underlying the Cambrian Frederick Limestone formation is the Antietam Formation, which is the upper member of the Precambrian to Cambrian Age Chilhowee Group. The Antietam Formation is white to dark gray and brown quartzite, that crops out less than 1,000 feet west of Area B. It is fine- to coarse-grained, with thin agillaceous partings. Bedding in the unit has been obscured by cleavage. The maximum thickness of the Antietam Formation is approximately 800 feet (Ref. 9, plate 1; Ref. 12; Ref. 35, pp. 41, 42).

Stratigraphically underlying the Antietam Formation is the Harpers Formation, which is a middle member of the Chilhowee Group. The Harpers Formation is a mixed phyllite and shale unit that crops out approximately 2,000 feet west of Area B. The shale is brown to dark bluish gray, and the phyllite is light bluish gray. The base of the unit is purple. Because the rocks are metamorphic, bedding throughout the unit has been obscured by cleavage. The maximum thickness of this unit is approximately 2,000 feet (Ref. 9, plate 1; Ref. 12; Ref. 35, p. 40).

Stratigraphically underlying the Harpers Formation is the Weverton Formation. This unit is a middle member of the Chilhowee Group and crops out approximately 1.0 mile west of Area B. The Weverton Formation is composed of interbedded, white to dark gray, thin-bedded quartzite and purple-banded phyllite. The quartzite may be micaceous, ferruginous, or sericitic. Some thick-bedded, ledge-forming quartzite and brown, ferruginous quartz conglomerate may occur. The maximum thickness of this unit is approximately 425 feet (Ref. 9, Plate 1; Ref. 12; Ref. 35, pp. 29, 34, 35, 37).

Stratigraphically underlying the Weverton Formation is the Loudoun Formation, which is a basal member of the Chilhowee Group. The Loudoun Formation is composed of an upper conglomeritic member and a lower phyllitic member. It crops out approximately 1.7 miles west of Area B. The upper member consists of quartz and granite pebblers in a phyllitic matrix. The lower member consists of pale purple discontinuous and lenticular phyllite. The maximum thickness of the Loudoun Formation is approximately 200 feet (Ref. 9, plate 1; Ref. 12; Ref. 35, pp. 29, 31).

Stratigraphically and unconformably underlying the Loudoun Formation is metarhyolites and associated pyroclastic sediments of late Precambrian age. The unit crops out as a small isolated occurrence approximately 4.2 miles northwest of Area B. The metarhyolites consists of a dense, blue cryptocrystalline matrix with white feldspar phenocrysts and glassy quartz. The pyroclastic sediments are composed of tuft breccia, blue slatey tuft, white tuffaceous sericitic schist, and banded green slate. The thickness of this unit is not known (Ref. 9, plate 1; Ref. 12; Ref. 35, p. 29).

The Catoctin Metabasalt stratigraphically and unconformably underlies the metaphyolite and associated pyroclastic sediments. The Catoctin Metabasalt is late Precambrian in age and corps out approximately 1 mile west of Area B. It is composed of thick-bedded metabasalt with amygdaloidal layers and secondary veins of quartz, calcite, and epidote. Interbeds of green tuffaceous phyllite and blue amygdaloidal metaandesite are also present. The thickness of this unit is unknown (Ref. 9, plate 1; Ref. 12; Ref. 35, pp. 20, 21).

The Ijamsville Formation crops out approximately 3.9 miles south-southeast of Area B. It is late Precambrian in age, but its stratigraphic relationship to the Catoctin metabasalt is not defined. The Ijamsville Formation is composed of blue, green, or purple phyllitic slate, which may be interbedded with metasiltstone or metagraywacke. Flattened pumiceous blebs may occur locally. The thickness of this unit is not known (Ref. 9, plate 1; Ref. 12).

The next youngest unit in stratigraphically descending order is the Triassic age diabase. This igneous intrusive rock occurs as dikes that unconformably contact most of the older geologic units in the Frederick Valley. The diabase dikes are composed of dense, greenish, resistant rock. The closest outcrop of this unit to Area B is approximately 32.0 miles to the northwest. The thickness of this unit is variable (Ref. 9, Plate 1; Ref. 12; Ref. 35, pp. 24, 25).

Karst

The Frederick Valley extends from the Potomac River northward to Woodsboro in Frederick County (Ref. 11, p. 3). The entire extent of the Frederick Valley has karst characteristics. The Frederick Valley is bound to the east by the Martic Fault (Ref. 11, p. 4), to the south by the Potomac River and to the west and north by Triassic rocks (Ref. 11, p. 7). The Gove and Frederick Limestone carbonate units of the Frederick Valley tend to exhibit features typical of karst terrain, including bedrock pinnacles, solution channels, and disappearing streams. Dissolution of limestones has resulted in surface features and drainage systems common to karst topography. The dissolution of the limestones creates cavities within the rocks that become enlarged, progressively integrating subsurface voids. An extensive underground drainage system of voids develops that results in a poorly developed surface network of streams. Karst topography is irregular and characterized by closed depressions or sinkholes, which form when voids develop very close to the ground surface, become unstable, and collapse. Sinkholes may develop along stream channels and capture or pirate surface water. Such a stream is commonly referred to as a “disappearing” stream. Springs are also common features in karst topography (Ref. 11, pp. i, 1, 3, 40, 41, 46). Solution cavities were frequently encountered in the Frederick Limestone in Area B to depths ranging from 10 to 186 feet bgs. The solution cavities usually occurred in series of voids and ledges up to 87 feet long. Sinkholes, disappearing streams, and springs are present in the southern portion of Area B (Ref. 5, p. 3-2; Ref. 8, p. 1-4).

One thousand and eight hundred and sixteen karst features have been identified and located with a global positioning system in the Frederick Valley of Frederick County. Active sinkholes make up approximately 34 percent of all identified karst features. Depressions are the most abundant karst features identified, and are most frequent in the Rocky Springs Station Member of the Frederick Formation and the Triassic Leesburg Formation (Ref. 11, pp. i, 40, and 41).

The Triassic sediments are considered karst because the sediments are detrital carbonate which exhibit karst characteristics. The western limit of the Triassic sediments is a linear fault along the eastern boundary of the Catoctin Mountain (Ref. 11, p. 7). The northern limit of the karst features of the Triassic sediments is Woodsboro, Maryland (Ref. 11, pp. 5, 6, and 7). Along the eastern margin of Catoctin Mountain is an outcrop belt underlain by detrital limestone of the Triassic Leesburg Formation. This region, just to the west of the Frederick Valley, exhibits karst surface features. The Triassic sediments in the region northwest of the City of Frederick exhibits kart terrane (Ref. 11, pp. 3 and 39). The karst regions in and surrounding Area B are shown in Figures 1 and 2 of Reference 11 and Plate 1 of Reference 11.

Area B Geology

Area B is underlain by fractured limestones and dolomites of the Frederick Formation in the southeastern portion of the area and by Triassic sedimentary units of the Oxford Formation in the north portion. A generalized geologic map of the units underlying the Area B is presented in Reference 8, Exhibit 1-7 (Ref. 8, p. 1-4, Exhibit 1-7).

The southern portion of Area B is underlain by limestones of the Frederick Formation, Rocky Springs Station Member. The Frederick Limestone has an approximate strike of North 35 degrees East and a dip of 50 degrees Southeast in the vicinity of Area B. The Frederick Limestone in Area B is characterized by dark gray, thin-bedded agillaceous limestone with numerous calcite-filled fractures. The lower portion of the Frederick Limestone consists of dark gray to black shale. The limestone weathers to reddish brown silty clay. This weathered limestone was observed in mud-filled fractures and voids during drilling and coring operations in Area B. Solution cavities were frequently encountered in the Frederick Limestone in Area B to depths ranging from 10 to 186 feet bgs. The solution cavities usually occurred in series of voids and ledges up to 87 feet long. Sinkholes, disappearing streams, and springs are present in the southern portion of Area B (Ref. 8, p. 1-4).

The Frederick Limestone is unconformably overlain by Triassic New Oxford Formation sediments and conglomerates in the northern portion of Area B (Ref. 11, pp. 4, 5, plate 1; Ref. 8, p. 4-1). The Triassic sediments consist of shale, sandstone, and siltstone units deposited by streams discharging into down-faulted basins from nearby uplands (Ref. 11 p. 36, plate 1; Ref. 8, p. 1-4, Exhibit 1-7). The northern portion of Area B is primarily underlain by the Triassic conglomerate, but there is a small area of shale-sandstone/siltstone in the northwestern area (Ref. 8, p.1-4, Exhibit 1-7).

The Triassic sedimentary units of the New Oxford Formation are characteristically red or maroon. The Triassic conglomerate of the New Oxford Formation is a quartz-pebble conglomerate north of Frederick and a limestone-pebble conglomerate south of Frederick. In some areas, the limestone clasts are predominant, with little or no matrix material, and can be mistaken for the Frederick Limestone (Ref. 11, p. 36; Ref. 9, pp. 1, 4, 6, 10, 11). This was observed in Area B core intervals as thick as approximately 20 feet. Distinguishing features are the lack of bedding in the conglomerate and the massive nature of the Frederick Limestone. Solution cavities up to 18 feet long have been encountered in the Triassic New Oxford Formation at depths ranging from 16 to 170 feet bgs (Ref. 8, pp. 1-4, 1-5).

The Triassic sedimentary units have an approximate strike of North 35 degrees East and a dip of 20 degrees northwest in the vicinity of Area B. The Triassic conglomerates are interpreted to be alluvial fan deposits or fanglomerates. As a result of this depositional environment, the conglomerates are interpreted to not have a true bedding strike and dip (Ref. 8, p. 1-5).

The time gap of the unconformity between the Triassic sedimentary units (approximate age 220 million years) and the Cambrian limestone (approximate age 520 million years) is approximately 300 million years. The approximate surface trace of the unconformity trends west to east across Area B. The unconformity is interpreted to be a zone of higher permeability, likely resulting from preferential seepage and flow of water along the Triassic/Cambrian contact. The surface trace of the unconformity has therefore been interpreted and mapped based on surface drainage features (Ref. 8, p. 1-5).

A contour map of the elevation of the top of the bedrock surface is presented in Reference 8, Exhibit 1-8. The depth to bedrock in Area B ranges from approximately 7 to 35 feet bgs. Bedrock is at the highest elevation in the area of the Triassic shale/sandstone/siltstone units in the northwestern portion of Area B. This area also correlates with a high in topography. Bedrock is also at a high elevation in the western portion of Area B. The elevation of the bedrock surface decreases to the east, and the surface itself becomes flatter (Ref. 8, p. 1-5).

Regional Hydrogeology

The individual geologic formations underlying Area B and the surrounding area are not simple, distinct aquifers because the water-bearing fractures may cut across contacts between lithologies having similarly low primary permeabilities, and intraformational differences may be as hydrologically significant as differences between formations (Ref. 9, pp. 17, 33). Aquifers in Frederick County occur within jointed and fractured bedrock. The heterogeneity of the geologic materials underlying the Fort Detrick facility results in large variability in aquifer properties within relatively small areas (Ref. 9, pp. 23, 33; Ref. 35, pp. 14, 15).

All of the geologic units within a 4-mile radius of Area B are water-bearing. Ground water occurs primarily under water-table conditions. The storage and movement of ground water occurs within the primary intergranular porosity of the unconsolidated sediments and within the secondary, fracture, and dissolution induced porosity of the consolidated rock units (Ref. 9, pp. 17, 24, 25, 33, 36; Ref. 10, pp. 9, 10; Ref. 36, pp. 13 through 17).

The hydraulic conductivities for the New Oxford Formation and Frederick Limestone residuum are based on laboratory analysis of core samples that did not include significant fractures; therefore, these estimated conductivities underestimate the large-scale or bulk hydraulic conductivities (Ref. 9, pp. 26, 27). Because both the New Oxford Formation and Frederick Limestone aquifers exhibit solution cavities and are highly fractured, the two aquifers are evaluated as karst aquifers. The limestone-pebble conglomerate hydrogeologic unit of the New Oxford Formation has superior water-bearing properties as a result of solution along bedding and joint planes; its water-bearing properties are similar to those of the Frederick and Grove Limestone aquifers in the Frederick Valley (Ref. 10, pp. 9, 10, 11, 12; Ref. 36, pp. 40, 41).

Bedrock aquifers are an important source of ground water in Frederick County. Overburden sediments are typically not important sources of ground water but serve to transmit surface water runoff to recharge the deeper aquifers. Ground water in bedrock occurs in joints, faults, and bedding plane partings. In the limestone units, secondary porosity as a result of solutional enlargement of joints, faults, and bedding plane partings are important. In the Triassic shales, sandstones, and siltstones, bedding plane partings are more important in transmitting ground water (Ref. 8, p. 1-3; Ref. 36, pp. 64 through 86).

Most ground water in Frederick County originates from the infiltration of local precipitation. Primary discharge zones are streams and springs. The Monocacy River is the major drainage feature of Frederick County and is likely a major ground water discharge point. A number of perennially flowing springs in Area B also serve as ground water discharge points (Ref. 8, p. 1-3).

Aquifer Discontinuity

The Catoctin Mountain, located approximately 1 mile west of Area B, is a geologic and hydrogeologic feature or structure that entirely transects aquifers underlying Area B (Ref. 11, plate 1; Ref. 12). The Catoctin Mountain prevents the flow of ground water and hazardous substances to the west of the mountain (Ref. 9, p. 22). Aquifers in the Blue Ridge Province, including the Catoctin Mountain and west of the Catoctin Mountain, are separated from aquifers in the Piedmont Providence, east of the Catoctin Mountain (Ref. 11, pp. 3, 6, 7, 39; Ref. 36, p. 8). The Catoctin Mountain is a northeastward trending ridge whose crests were formed by metabasalt and aporhyolite of Precambrian age (Ref. 36, p. 8). The Middletown Valley, located along the western border of the Catoctin Mountain, is underlain by granodiorite and granite gneiss of Precambrian age (Ref. 36, p. 10). The Catoctin Mountain encloses no beds higher than Weverton quartzite. It is believed that the younger formations were formerly present and have been removed by erosion (Ref. 35, p. 104). Although the Frederick syncline (Frederick Valley) is just east of the Catoctin Mountain syncline, the Frederick syncline is not regarded as part of the deeper part of the Catoctin Mountain syncline in which higher beds are preserved because of their down-dropped positions (Ref. 35, p. 114).

The differences in elevations of aquifers in the Catoctin Mountain and in the Frederick Valley separate the aquifers. The elevations in Area B of Fort Detrick range from 340 to 400 feet above sea level (Ref. 42). The nearby elevations on the Catoctin Mountain range from 600 to 1,600 feet above sea level (Ref.19; Ref. 42).

The east margin of the Catoctin Mountain is an outcrop belt underlain by detrital limestone of the Triassic Lessburg Formation and exhibits considerable karst surface features and is therefore, considered part of the Frederick Valley aquifers (Ref. 11, pp. 3 and 39). The bedrock along the eastern border of the Catoctin Mountain is mapped as the Rocky Springs Station Member of the Frederick Formation and is covered by colluvium (Ref. 11, pp. 3, 6, 7, 39).

Area B Hydrogeology

The ground water contained within the various formations and members of the formations underlying Area B and within a 4 mile radius of sources on Fort Detrick Area B Ground Water, is evaluated as one aquifer, the Frederick Valley Bedrock aquifer. The formations and members include the Antietam, Balls Bluff Siltstone, Catoctin Metabasalt, Colluvium, Frederick, Harpers, Leesburg, Loudoun, Manassas, Maryland Heights, New Oxford, Owens, Creek, and Poolesville (Ref. 12). No confining layers have been identified within Frederick Valley aquifers. As documented in the geology section of this report, the formations underlying Area B are highly fractured, and some are karst. No barriers to ground water flow between the aquifers have been identified. Confining layers may occur in all units but are of discontinuous lateral extent. Thus, they function as semiconfining layers and are not considered to function as barriers to ground water flow. Because of the absence of regionally continuous confining layers and the presence of fractures within the consolidated units, all of the units within the Frederick Valley are considered to be hydrologically interconnected (Ref. 9, pp. 17, 23, 24, 25, 33; Ref. 33; Ref, 36, pp. 13 through 17, 40, 41).

Static water level measurements recorded during Area B periodic ground water sampling events indicate that ground water in Area B likely flows east-southeast toward springs that drain into Carroll Creek and ultimately to the Monocacy River (Ref. 8, p. 1-3). Ground water elevations mimic the topographic elevations (Ref. 5, Exhibit 3-9; Ref. 34; Ref. 42). The topography of Area B is relatively flat with elevations up to 400 feet above mean sea elevation (msl) in the western portion and elevations of 340 feet above msl in the eastern portion. The distance from the western boundary of Area B and to the eastern boundary is about 1 mile (Ref. 4, p. I-8; Ref. 19; Ref. 42).

A dye trace study was conducted in Area B in 1995. The study results suggest that contaminants introduced into the upper portion of the aquifer in Area B would be preferentially discharged to an area southeast of Area B. This area includes a privately owned complex of springs (Robinson’s Box and Rock Springs near Robinson’s Pond) and Carroll Creek. Based on the estimated straight-line travel rate of fluorescein and eosine dyes used in the dye trace study, it is estimated that ground water flows at a rate of about 79 to 246 feet per day, with a mean value of 151 feet per day (Ref. 8, p. 1-3).

3.1 LIKELIHOOD OF RELEASE

3.1.1 OBSERVED RELEASE

Aquifer Being Evaluated: Frederick Valley Bedrock Aquifers

All aquifers underlying sources at the Area B are interconnected as documented in Section 3.0 and are evaluated as one aquifer, the Frederick Valley Bedrock aquifer.

Chemical Analysis

In 1991 and 1992, ground water contamination was identified in Area B. TCE was detected in a monitoring well FR-81-4728, north of Source 1, and in monitoring well M-3A, east of Source 1 (Ref. 13). No background well samples were provided with this data. Therefore, this data is not used to document an observed release to ground water.

In 1992, TCE was detected in residential well samples collected south of Area B (Ref. 25; Ref. 41; Ref. 47). Observed releases to these wells are documented.

Ground water sampling in Area B has periodically been performed since 1995 (Ref. 21; Ref. 22; Ref. 23, p. 1-1). All samples were collected in accordance with Technical Addendum I to the work plan prepared by Shaw Environmental dated January 2005 and the Phase III RI Area B work plan prepared by Shaw Environmental dated January 2005 (Ref. 29; Ref. 49). Off-facility ground water samples were collected from residences currently connected to the City of Frederick water system or provided with bottle water by the Fort Detrick facility (Ref. 23, p. 4-2; Ref. 24). References 21 and 22 summarize all the ground water sampling events since 1995. Analytical data from September 2005 were used to document an observed release to ground water. All data were validated using EPA protocols for data validation (Ref. 23, pp. 3-2 to 3-4). The ground water samples were analyzed for VOCs using EPA SW-846, Method 8260B (Ref. 23, p. 3-1). The detection limits are at or below EPA MCLs (Ref. 23, p. 3-2). The data validation reports for the 2005 ground water data are provided in Reference 23, Appendix C. Analytical data from 2006 are provided in Ref. 32.

Ground water contamination from Area B has forced the City of Frederick to limit potential locations for new municipal wells (Ref. 7, p. 2). Investigations have concluded that the buried materials in Area B-11 (Source 1) are the source of TCE and PCE contamination detected in both Area B and off site ground water wells (Ref. 7, p. 1-2; Ref. 29, pp. 2-6 and 2-7).

1992 - Background Wells

In October and November1992, the Maryland Department of the Environment (MDE) and the Frederick County Health Department collected residential well samples (Ref. 47, p. 4-21). The analytical results document an observed release of TCE to several residential wells. References 25, 51 and 52 summarize the analytical data that were sent to EPA, notifying EPA of the residential well contamination. The sampling locations are summarized in Reference 41 and Reference 47, Exhibits 4-40 and 4-41. The residents were subsequently provided with bottled water or connected to public water (Ref. 24; Ref. 29, p. 2-6; Ref. 47, p. 4-21). Two of the sampling locations, A-Kemp Lane and B-Rock Springs Road were located upgradient of Source 1, based on the prevalent ground water flow direction in Area B. The prevalent ground water flow direction is west to the east, southeast (Ref. 5, p. 2-1, 3-4, Exhibit 3-9; Ref. 8, p. 1-3, Exhibit 1-6; Ref. 23, p. 4-1, Exhibit 2-4; Ref. 29, p. 2-6; Ref. 32, Exhibit 2-4; 54). These two wells are used to document background concentrations for the residential wells sampled in 1992.

Well logs for the specific residential wells sampled in October 1992 are not available. However, residential wells in Frederick County, Maryland, are completed in bedrock (Ref. 36 pp. 64 through 86 and pp. 134 through 228). Well logs from other wells located in the vicinity of the 1992 residential well sampling locations are provided in Reference 44. The well logs indicated that the depths of residential wells within the vicinity of Area B range from 50 to 400 feet below ground surface. The well logs indicate that residential wells are completed within intervals that include ground water from both shallow and deep or only shallow portions of the aquifer. Therefore, the residential wells are drawing from the same depths of the aquifer. The residential wells located upgradient and west of Source 1 are considered background wells. These wells are considered to be comparable to the residential wells located downgradient and east or southeast of Source 1 because the wells draw from the same aquifer and from the same relative depths within the aquifer. Although some of the residential wells may be deeper than others, the screened interval within the wells begin at shallows depths and continue to deeper intervals, drawing water from the shallow and deep portions of the aquifer (Ref. 44). Table 5 summarizes the 1992 sampling information for the background residential wells.

TABLE 5
1992- BACKGROUND WELL

Well No.	Well Type	Date	Reference
B-Rock Springs Lane	Residential well	10/7/1992	25, p. 3; 41; 47, p. 4-22; 54
A-Kemp Lane	Residential well	10/7/1992	25, p. 3; 41; 54

Background well concentrations are summarized in Table 6.

TABLE 6
1992 - BACKGROUND WELL CONCENTRATIONS

Hazardous Substance	Concentration (µg/L)	MDL (µg/L)	Date	Reference
B-Rock Springs Lane				
1,1,1-Trichloroethane	ND	0.2	11/3/1992	25, p. 3; Ref. 51, pp. 3, 23; 54
Trichloroethene	ND	0.2	11/3/1992	25, p. 3; Ref. 51, pp. 3, 23; 54
Tetrachloroethene	0.6	0.2	11/9/1992	25, p. 3; Ref. 51, pp. 3, 23; 54
A-Kemp Lane				
1,1,1-Trichloroethane	ND	0.2	10/7/1992	25, p. 3; Ref. 51, pp. 3, 23; 54
Trichlorethene	ND	0.2	10/7/1992	25, p. 3; Ref. 51, pp. 3, 23; 54

Notes:
The analytical data sheet for B-Rock Springs Lane is not available. The data sheet for A-Kemp Lane was used to determine the method detection limit because the samples were analyzed using the same method.
MDL = Method detection limit
µg/L = micrograms per liter

2005 – Background Wells

An observed release to ground water is documented in 2005. The screened intervals of the background and release wells are measured from the top of casing (feet below the ground surface [bgs]). The length of the casing is not recorded. The depths of the screened intervals based on measurements taken at the ground surface are comparable because ground water and bedrock elevations mimic the topographic elevations and the topography of Area B is relatively flat (Ref. 5, Exhibits 3-7 and 3-9; Ref. 42). The surface of Area B has elevations up to 400 feet above msl in the western portion and elevations of 340 feet msl in the eastern portion. The distance from the western boundary of Area B and to the eastern boundary is about 1 mile (Ref. 4, p. I-8; Ref. 42). Bedrock is at the highest elevation in the area of the Triassic shale/sandstone/siltstone units in the northwestern portion of Area B. The elevation of the bedrock surface decreases to the west, and the surface itself becomes flatter. The elevation of bedrock in the southeastern portion of Area B is 310 feet above msl (Ref. 5, Exhibit 3-7; Ref. 8, p. 1-5). Ground water elevations are the highest in the northwest portion of Area B, 385 feet above msl, and the lowest in the eastern portion of Area B, 325 feet above msl (Ref. 5, Exhibit 3-9). These elevations correlate with the topography in Area B (Ref. 42). The background and release wells are comparable because the monitoring wells are completed at the same relative depths within the aquifer underlying Area B.

Ground water sampling data from 2005 document an observed release to ground water. Two wells were selected as background locations based on ground water flow direction as documented from ground water contours. The 2005 background and the release wells are completed within the deep karst aquifer. The monitoring wells with the letter "D" following the well number are the deep karst aquifer monitoring wells. Reference documentation does not define the deep karst aquifer. Based on depths and screened intervals of wells, the deep karst aquifer is the aquifer between 70 and 183 ft bgs (Ref. 23, Appendix A).

Background well details are summarized in Table 7. The background well BMW 11D is located along the northeastern boundary of Area B and background well BMW 55D is located along the western boundary of Area B (Ref. 23, Exhibits 2-4, 4-2, and 4-3; Ref. 5, p. 2-1). BMW 55D was installed to assess the quality of the ground water flowing onto Area B (Ref. 47, p. 4-27). The screened intervals presented in Table 7 were recorded during the 2005 sampling event and may differ from the original well logs for the monitoring wells. This difference is due to different locations from which the measurements were taken. All measurements taken during the 2005 sampling event were taken from the top of casing (TOC) (Ref. 23, Appendix A). Well log measurements were taken from the TOC and from the ground surface (Ref. 46).

TABLE 7
2005 - BACKGROUND WELLS

Well Number	Screened Interval (ft bgs)[a]	Ground Water Elevation (ft above msl)	Approximate Bedrock Elevation (ft above msl)	Date	Reference
BMW-11D	153 - 163	335.58	340	9/13/2005	23, Appendix A, well purge log for BMW 11D, Exhibit 2-4; 46, pp. 1 to 5; 8, Exhibit 1-8
BMW-55D	70 – 90	355.04	370	913/2005	23, Appendix A, well purge log for BMW 55D, Exhibit 2-4; 46, pp. 29 to 32; 8, Exhibit 1-8

Notes:
bgs = below ground surface
ft = feet
msl = mean sea level
[a]The depth to the screened interval was measured from the top of the casing.

TABLE 8
2005 - BACKGROUND WELL CONCENTRATIONS

Hazardous Substance	Concentration (µg/L)	SQL (µg/L)	Reference
Well No. BMW 11D: Sample date September 13, 2005			
Benzene	ND	1.0	23, Appendix A, p. 4; Appendix B, p. 1; and Appendix C, p. 26
1,1,1-Trichloroethane	ND	1.0	23, Appendix A, p. 4; Appendix B, p. 1; and Appendix C, p. 26
1,2-Dichloroethane	ND	1.0	23, Appendix A, p. 4; Appendix B, p. 1; and Appendix C, p. 26
1,1-Dichloroethene	ND	1.0	23, Appendix A, p. 4; Appendix B, p. 1; and Appendix C, p. 26
1,2-Dichloroethene	ND	1.0	23, Appendix A, p. 4; Appendix B, p. 1; and Appendix C, p. 26
Chloroform	ND	1.0	23, Appendix A, p. 4; Appendix B, p. 1; and Appendix C, p. 26
Cis-1,2-Dichloroethene	ND	1.0	23, Appendix A, p. 4; Appendix B, p. 1; and Appendix C, p. 27
Tetrachloroethene	0.24 J	1.0	23, Appendix A, p. 4; Appendix B, p. 1; and Appendix C, p. 26
Trichloroethene	ND	1.0	23, Appendix A, p. 4; Appendix B, p. 1; and Appendix C, p. 27
Vinyl chloride	ND	1.0	23, Appendix A, p. 4; Appendix B, p. 1; and Appendix C, p. 27
Well No. BMW 55D: Sample date: September 13, 2005			
Benzene	ND	1.0	23, Appendix A, p. 2; Appendix B, p. 1; and Appendix C, p. 34
1,1,1-Trichloroethane	ND	1.0	23, Appendix A, p. 2; Appendix B, p. 1; and Appendix C, p. 34
1,2-Dichloroethane	ND	1.0	23, Appendix A, p. 2; Appendix B, p. 1; and Appendix C, p. 34
1,1-Dichloroethene	ND	1.0	23, Appendix A, p. 2; Appendix B, p. 1; and Appendix C, p. 34
1,2-Dichloroethene	ND	1.0	23, Appendix A, p. 2; Appendix B, p. 1; and Appendix C, p. 34
Chloroform	ND	1.0	23, Appendix A, p. 2; Appendix B, p. 1; and Appendix C, p. 34
Cis-1,2-Dichloroethene	ND	1.0	23, Appendix A, p. 2; Appendix B, p. 1; and Appendix C, p. 35
Tetrachloroethene	0.21J	1.0	23, Appendix A, p. 2; Appendix B, p. 1; and Appendix C, p. 34
Trichloroethene	ND	1.0	23, Appendix A, p. 2; Appendix B, p. 1; and Appendix C, p. 35
Vinyl chloride	ND	1.0	23, Appendix A, p. 2; Appendix B,

			p. 1; and Appendix C, p. 35

Notes:
μg/L = Micrograms per liter
J = Estimated concentration. Sample concentration ≥ MDL and < MRL or < 3*MDL, whichever is greater. No adjustment required because there is no bias. (Ref. 23 Appendix C, pp. 7, 9, 26, 34; Ref. 37).
ND = Not detected
SQL = Sample quantitation limit

1992 Contaminated Samples

The samples collected in 1992 from residential and business establishment wells in the vicinity of Area B documented an observed release of TCE and 1,1,1-TCA to ground water and residential wells. The wells with observed releases of TCE, PCE, and 1,1,1-TCA are summarized in Table 9. A discussion of background and release comparability is provided in the section entitled 1992 Background Samples. The sampling locations are shown in Reference 41. The background well information is presented in Tables 5 and 6.

TABLE 9
1992 WELL RELEASE CONCENTRATIONS

Sample Identification Number	Hazardous Substance	Conc. (μg/L)	MDL (μg/L)	Reference
C-Montevue	Trichloroethene	18	0.2	25, p. 2; 51, pp. 1, 18; 52, p. 6; 54
C-Montevue	Tetrachloroethene	17	0.2	25, p. 2; 51, pp. 1, 18; 54
D-Montevue	Trichloroethene	2	0.2	25, p. 2; 51, p. 24; 52, p. 1; 54
G-Montevue	Trichloroethene	19		25, p. 2; 51, p. 19; 52, p. 3; 54
H-Montevue	Trichloroethene	1	0.2	25, p. 2; 51, p. 21; 52, p. 4; 54
E-Montevue (40 W Exxon)	Trichloroethene	3	0.2	25, p. 2; 51, pp. 1, 20; 52, p. 2; 54
F-Montevue	Trichloroethene	4.9	0.2	51, pp. 1, 22
I-Shookstown	1,1,1-Trichloroethane	2.7	0.2	25, p. 3; 51, pp. 2, 22; 54

Notes:
The analytical data sheets for F-Montevue and I-Shookstown Road are not available. The data sheet for A-Kemp Lane was used to determine the method detection limit because the samples were analyzed using the same method.

MDL = Method detection limit
µg/L = micrograms per liter

There is no record of D-Montevue or I-Shookstown being connected to public water (Ref. 47, pp. 4-21 and 4-22; Ref. 54).

2005 Contaminated Samples

The analytical data provided in Table 10 summarize the 2005 ground water sampling data for Area B. Reference 21 provides a summary of all on-facility ground water analytical data from 1995 to July 2005. Reference 22 provides a summary of all off-facility ground water analytical data for the same time frame. The off-facility ground water sampling data include closed residential wells. The wells were closed due to the contamination released from Area B and the residents were connected to the City of Frederick water supply. Several domestic wells are used for all purposes except for drinking water. Fort Detrick provides those residents with bottled water for drinking (Ref. 24; Ref. 29, p. 2-6). The residential wells that were closed because of the ground water plume are located along Shookstown Road and Montevue Lane as shown in Reference 23, Exhibits 2-1, 2-4, 4-2, and 4-3.

The residential well DWSRD-26 for which an observed release can be documented is located on Shookstown Road, on the southern part of Shookstown as shown in Reference 23, Exhibit 2-1 (Ref. 23, Exhibits 2-1, 2-4, 4-2, and 4-3; Ref. 50, p. 1). The ground water elevations shown on Exhibit 2-4 of Reference 23, indicate that the residential well (DWSRD-26) identified as residential 26 is located downgradient of Source 1. Records indicate that the residents are provided with bottled water for drinking (Ref. 47, pp. 4-21 and 4-22). The screened intervals presented in Table 10 were recorded during the 2005 sampling event and may differ from the original well logs for the monitoring wells. This difference is due to different locations from which the measurements were taken. All measurements taken during the 2005 sampling event were taken from the top of casing (TOC) (Ref. 23, Appendix A). Well log measurements were taken from the TOC and from the ground surface (Ref. 46).

TABLE 10
2005 GROUND WATER RELEASE SAMPLES

Sample Identification	Screened Interval (feet bgs)[a]	Ground Water Elevation (ft above msl)	Approximate Bedrock Elevation (ft above msl)	Date	Reference
BMW 31D	169 to 179	334.40	310	09/15/2005	23, Appendix A, p. 17 and Exhibit 2-4; 46, pp. 6 to 13; 8,

Sample Identification	Screened Interval (feet bgs)[a]	Ground Water Elevation (ft above msl)	Approximate Bedrock Elevation (ft above msl)	Date	Reference
					Exhibit 1-8
BMW 37D	112 to 122	343.35	340	09/15/2005	23, Appendix A, p. 21 and Exhibit 2-4; 46, pp. 20 to 23
BMW 54D	147 to 177	340.09	320	09/15/2005	23, Appendix A, p. 1 and Exhibit 2-4; 46, pp. 24 to 28
BMW 57D	102 to 122	343.39	350	09/15/2005	23, Appendix A, p. 15 and Exhibit 2-4; 46, pp. 33 to 37
BMW 58D	109 to 129	349.73	360	09/15/2005	23, Appendix A, p. 13 and Exhibit 2-4; 46, pp. 38 to 42
BMW 59D	163 to 183	348.09	350	09/15/2005	23, Appendix A, p. 10 and Exhibit 2-4; 46, pp. 43 to 48
DWSRD-26	Residential well; not available	Residential well; not available	Residential well; not available	09/15/2005	23, p. 4-2
DWGRAN-18	Residential well; not available	Residential well; not available	Residential well; not available	9/15/2005	23, p. 4-2

Notes:
bgs = Below ground surface
[a]The depth to the screened interval was measured from the top of the casing.

In September 2005 periodic ground water samples were collected from the Fort Detrick facility and off-facility residential wells (Ref. 23, p. 1-1). Table 11 summarizes detections exceeding three times the background concentrations or exceeding the detection limits if the compound was not detected in the background wells. The background well information for these release wells is presented in Tables 7 and 8.

TABLE 11
GROUND WATER RELEASE CONCENTRATIONS

Sample Identification Number	Hazardous Substance	Conc. (µg/L)	SQL (µg/L)	Reference
Date: September 2005				
BMW 31D	TCE	3.3	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 71
BMW 37D	1,1,1-TCA	2.5	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 115
BMW 37D	1,1-DCE	8.4	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 115
BMW 37D	cis-1,2-DCE	6.9	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 116
BMW 37D	PCE	2.8	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 115
BMW 37D	TCE	61	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 116
BMW 54D	TCE	7.2	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 11
BMW 57D	1,1,1-TCA	30	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 52
BMW 57D	1,1-DCE	7.9	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 52
BMW 57D	1,2-DCA	14	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 52
BMW 57D	Benzene	33	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 52
BMW 57D	Vinyl chloride	48	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 53
BMW 58D	1,1,1-TCA	4.2	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 42
BMW 58D	1,1-DCE	15	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 42
BMW 58D	1,2-DCE	1.2	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 42
BMW 58D	Chloroform	34	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 42

Sample Identification Number	Hazardous Substance	Conc. (µg/L)	SQL (µg/L)	Reference
BMW 58D	cis-1,2-DCE	8.6	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 43
BMW 58D	PCE	4.7	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 42
BMW 59D	1,1,1,-TCA	2.2	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 50
BMW 59D	1,1-DCE	6.2	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 50
BMW 59D	Chloroform	18	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 50
BMW 59D	PCE	1.4	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 50
BMW 59D	TCE	48	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 51
BMW 59D	1,2-cis-DCE	2.2	1.0	23, p. 4-1, Exhibit 4-1, Appendix B, p. 3, Appendix C, p. 51
DWSRD-26	TCE	1.2	1.0	23, p. 4-2, Exhibits 4-1 and 4-2, Appendix B, p. 2, Appendix C, p. 75
DWGRAN-18	PCE	1.6	1.0	23, p. 4-2, Exhibits 4-1 & 4-3 and Appendix C, p. 94;

Notes:

µg/L	=	Micrograms per liter
Conc.	=	Concentration
DCA	=	Dichloroethane
DCE	=	Dichloroethene
PCE	=	Tetrachloroethene
SQL	=	Sample quantitaton limit
TCA	=	Trichloroethane
TCE	=	Trichloroethene

Level I Samples

As documented in the table below, Level I concentrations were detected in eight drinking water wells. The contamination was originally identified in October 1992. The residents were subsequently provided with bottled water or were connected to public water (Ref. 24; Ref. 25; Ref. 29, p. 2-6; 47, p. 4-21). The concentrations detected in the wells are documented in Tables 9 and 11.

TABLE 12
LEVEL I CONCENTRATION

Sample ID	Hazardous Substance	Concentration (µg/L)	Benchmark CRS (µg/L)	Benchmark MCL (µg/L)	Reference
DWSRD-26	Trichloroethene	1.2	0.21	5	23, p. 4-2, Exhibit 4-1 and Appendix C, p. 75; 54; 2, p. A-1
DWGRAN-18	Tetrachloroethene	1.6	1.6	5	23, p. 4-2, Exhibits 4-1 and 4-3, and Appendix C, p. 94; 54; 2, p. BII-11
C-Montevue	Trichloroethene	18	0.21	5	25, p. 2; 54; 2, p. A-
C-Montevue	Tetrachloroethene	17	1.6	5	25, p. 2; 54; 2, p. BII-11
D-Montevue	Trichloroethene	2	0.21	5	25, p. 2; 2, p. A-1; 54
G-Montevue	Trichloroethene	19	0.21	5	25, p. 2; 2, p. A-1; 54
H-Montevue	Trichloroethene	1	0.21	5	25, p. 2; 2, p. A-1; 54
E-Montevue (40 W Exxon)	Trichloroethene	3	0.21	5	25, p. 2; 2, p. A-1; 54
F-Montevue	Trichloroethene	4.9	0.21	5	51, p1; 2, p. A-1; 54

Notes:
µg/L = Micrograms per liter
CRS = Cancer risk screening concentration
ID = Identification
MCL = Maximum Contaminant Level

Attribution

TCE was known to have been disposed of in Area B-11 (Ref. 7, pp. 2-1, 2-3, 2-4). Soil samples collected from Area B-11 contained TCE (Ref. 7, p. 2-2, Appendix B). A soil sample from Pit 1 contained TCE at 1,200 µg/kg; PCE at 4,200 µg/kg; ethylbenzene at 2,700 µg/kg; carbon tetrachloride at 1,800 µg/kg; xylene at 18,000 µg/kg; and 1,2,4-trichlorobenzene at 93,000 µg/kg (Ref. 7, Exhibit 2). During excavation in Area B-11, a containment system was constructed over Area B-11 that included a carbon air filtration system. TCE, PCE, and carbon tetrachloride were detected at high concentrations in the air filter carbon samples (Ref. 7, pp. 1, 2-4, and Exhibit 2). A total of 22 pounds of VOCs were captured in the carbon units (Ref. 7, p. 2-4). TCE was detected in the carbon samples up to 63,000 µg/kg (Ref. 7, Exhibit 2).

Materials containing TCE and PCE were present in wastes disposed of in Area B-11 (pit 1) (Ref. 7, p. 1). Soil gas samples in Area B-11 have contained TCE and PCE (Ref. 7, p. 1). Ground water investigations have identified Area B-11 as a source of TCE and PCE ground water contamination (Ref. 7, p. 1-1).

Benzene, chloroform, and 1,2-DCA were detected in two of the 14 soil samples collected from pits in Source 1 (Ref. 7, Appendix B, table entitled "TCL VOC TAL SVOC and TAL and Metals Results Collected During Test Trenching Activities").

TCE breaks down into DCE and vinyl chloride. The presence of DCE and vinyl chloride in ground water is attributed to the breakdown of TCE (Ref. 31). A review of ground water contours and isoconcentrations indicates that 1,1,1-TCA is from Area B of the Fort Detrick facility (Ref. 23, Exhibit 2-4 and 4-1 to 4-4). No other source of these substances has been identified. Area B of the Fort Detrick facility encompasses 399 acres and dominates the land in the study area. Land use surrounding the Area B includes schools and residential areas (Ref. 4, pp. ii, I-3; Ref. 42).

<u>Hazardous Substances in Observed Release:</u>

- Benzene
- Chloroform
- 1,2-DCA
- 1,1-DCE
- 1,2-DCE
- cis-1,2-DCE
- PCE
- 1,1,1-TCA
- TCE
- Vinyl chloride

Ground Water Observed Release Factor Value: 550.00

3.2 WASTE CHARACTERISTICS

3.2.1 TOXICITY/MOBILITY

The Table 13 summarizes the toxicity and mobility factor values for the hazardous substances associated sources at the facility and in the observed releases to ground water. The values are assigned in accordance with Section 3.2.1 of Reference 1. The mobility and toxicity values were obtained from Reference 2. If a hazardous substance was detected in the observed release to ground water a mobility value of 1 is assigned. Because Area B overlies both karst and non-karst aquifers, the non-karst aquifer mobility factor values are used.

TABLE 13
TOXICITY/MOBILITY FACTOR VALUES

Hazardous Substance	Source No.	Toxicity Factor Value	Mobility Factor Value	Toxicity/ Mobility Factor Value	Reference
Acetone	1	10	1	10	2, p. BI-1
Aroclor-1254	1, 2	10,000	2.00E-07	2.00E-03	2, p. BI-10
Aroclor-1261	1	10,000	2.00E-07	2.00E-03	2, p. BI-10
Benzene	1	1,000	1*	1,000	2, p. BI-2
Beryllium	2	10,000	1.00E-02	100	2, p. BI-2
Cadmium	3, 4	10,000	1.00E-02	100	2, p. BI-2
Carbon tetrachloride	1	1,000	1	1,000	2, p. BI-3
Chloroform	1	100	1*	100	2, p. BI-3
Chromium	2, 3	10,000	1.00E-02	100	2, p. BI-3
Cobalt	2, 4	10	1.00E-02	0.10	2, p. BI-3
Copper	4	0	1.00E-02	0	2, p. BI-3
1,2-Dichloroethane	1	100	1*	100	2, p. BI-4
1,1-Dichloroethene	1	100	1*	100	2, p. BI-5
1,2-Dichloroethene	1	100	1*	100	2, p. BI-5
Ethyl benzene	1	10	1	10	2, p. BI-6
Fluoranthene	2	100	2.00E-07	2.00E-05	2, p. BI-2
Phenanthrene	2	0	2.00E-05	0	2, p. BI-9
Pyrene	2	100	2.00E-05	2.00E-03	2, p. BI-10
Mercury	3, 4	10,000	1.00E-02	100	2, p. BI-8
Nickel	3, 4	10,000	1.00E-02	100	2, p. BI-9
Tetrachloroethene	1	100	1*	100	2, p. BI-10
Thallium	2, 3	100	1.00E-02	1	2, p. BI-11
Toluene	1	10	1	10	2, p. BI-11
1,2,4-Trichlorobenzene	1	100	2.00E-01	20	2, p. BI-11

Hazardous Substance	Source No.	Toxicity Factor Value	Mobility Factor Value	Toxicity/ Mobility Factor Value	Reference
1,1,1-Trichloroethane	NA	1	1*	1	2, p. BI-11
Trichloroethene	1	10,000	1*	10,000	2, p. A-2
Xylene	1	100	1.00E-02	100	2, p. BI-12
Vinyl chloride	NA	10,000	1*	10,000	2, p. BI-12
Zinc	4	10	1	10	2, p. BI-12

Note:
* = Documented in the observed release to ground water. A mobility factor value of 1 is assigned (Ref. 1, Section 3.2.1.2).
NA = Documented in the observed release to ground water. Substance is a breakdown product of PCE (Ref. 53).

Toxicity/Mobility Factor Value: 10,000
(Ref. 1, Table 3-9)

3.2.2 HAZARDOUS WASTE QUANTITY

The hazardous waste quantity values for the sources at Area B of the Fort Detrick facility are summarized in the table below.

TABLE 14
HAZARDOUS WASTE QUANTITY VALUES

Source No.	Source Type	Source Hazardous Waste Quantity
1	Landfill	1.1072
2	Landfill	16.6553
3	Contaminated soil	> 0
4	Contaminated soil	> 0

Sum of Values: 17.7625

The hazardous waste quantity value of 100 is assigned to the ground water migration pathway because observed releases to ground water and actual contamination at Level I concentrations in drinking water wells are documented. If any target for a migration pathway is subject to Level I concentrations, a value of 100 is assigned if the value obtained from Table 2-6 of Reference 1 is less than 100 (Ref. 1, Section 2.4.2.2).

Hazardous Waste Quantity (HWQ) Factor Value: 100

3.2.3 WASTE CHARACTERISTICS FACTOR VALUE

The waste characteristics factor value is assigned based on the product of the HWQ factor value (100) and the highest toxicity/mobility factor value (10,000). Based on the total waste characteristics product of 1,000,000, a HWQ factor value is assigned from Table 2-7 of Reference 1. The waste characteristics factor value is 32.

Waste Characteristics Factor Category Value: 32
(Ref. 1, Table 2-7)

3.3 TARGETS

The ground water targets evaluated for the ground water migration pathway are summarized below.

3.3.1 NEAREST WELL

The nearest known drinking water wells are located on the southern border of the facility. The well locations are shown in Exhibits 2-1, 2-4, and 4-2 of Reference 23. Because actual contamination at Level I concentrations has been documented, a nearest well factor value of 50 is assigned (Ref. 1, Section 3.3.1, Table 3-11).

Nearest Well Factor Value: 50
(Ref. 1, Table 3-11)

3.3.2 POPULATION

3.3.2.1 Level of Contamination

3.3.2.2 Level I Concentrations

In 1992 Level I concentrations of TCE were detected in wells as documented in Tables 9 and 12 of this documentation record. The residents were subsequently provided with bottled water or were connected to public water supplies (Ref. 23, pp. 1-1, 4-1, and 4-2; Ref. 24; Ref. 47, pp. 4-21 and 4-22; Ref. 25; Ref. 51). Notes on the 1992 residential well data faxed to EPA identify the following populations associated with each sampling location: C-Montevue, large family; Stull's House of Design (D-Montevue), none identified; SKS Corporation (G-Montevue), six full time people; H-Montevue, none identified; I-Shookstown Road, none identified; 40 W Exxon (E-Montevue) none identified (Ref. 25; Ref. 54). The population used for the residential wells for which no population was identified, is the average number of persons per household in 1990, the last published census data at the time of sampling. That population is 2.78 (Ref. 48). The 1990 average persons per house was not used to estimate the populations at D-Montevue and E-Montevue; for these two wells with unknown population, a worker population of 1 is assumed for each location. These populations are used because they are populations associated with the wells when the wells were used for drinking water.

In 2005, Level I concentrations were detected in two residential wells (one located at DWSD-26 and another at DWGRAN-18) as documented in Tables 11 and 12 of this documentation record. (Ref. 23, pp 4-2, Exhibits 4-1 and 4-2, Appendix B, p. 2, Appendix C, p. 75; Ref. 24; Ref. 41; Ref. 47, pp. 4-21 and 4-22; Ref. 54). The population served by the well is the average number of persons per household for Frederick County, Maryland in the year 2000 or 2.72 persons (Ref. 20).

As documented in the geology and hydrogeology sections of this HRS documentation record, the aquifers underlying Area B and within the Frederick Valley are interconnected. Based on Reference 12, Geologic Map of Frederick County, Maryland, the Level I residential wells are completed in the Frederick Formation and colluvium. The table below summarizes the Level I population.

TABLE 15
LEVEL I POPULATION

Level I Well	Aquifer No.	Population	Reference
DWSRD-26	1	2.72	20; 54
C- Montevue	1	2.78	25, p. 2; 48; 54
D-Montevue	1	1*	25, p. 2; 54
E-Montevue	1	1*	25, p. 2; 54
F-Montevue	1	2.78	51, p. 1; 48; 54
G-Montevue	1	6	25, p. 2; 54
H-Montevue	1	2.78	25, p. 2; 48; 54
DWGRAN-18	1	2.72	20; 54

* = Actual worker count is not available. A population of at least one worker is used.

Sum of Population Served by Level I Wells: 21.78
Level I Population (21.78 × 10): 217.8
Level I Concentrations Factor Value: 217.8 (Ref. 1, Section 3.3.2.2)

3.3.2.3 Level II Concentrations

Level II concentrations have not been evaluated.

Sum of Population Served by Level II Wells: 0

Level II Concentrations Factor Value: 0 (Ref. 1, Section 3.3.2.3)

3.3.2.4 Potential Contamination

Residents within the 4-mile distance categories from Area B obtain drinking water from both surface water and ground water sources. None of the surface water intakes are located within the surface water migration pathway of Area B. Drinking water wells are used for both domestic and public water supplies. The wells draw water from one of the many formations underlying Area B. As documented in the Section 3.0, aquifers within the formations are interconnected; however, some of the formations are karst and others are fractured bedrock. Distance-weighted population values for potential contamination are assigned differently for karst and other aquifers (fractured bedrock) (Ref. 1, Table 3-12); therefore, ground water targets associated with karst formations are evaluated separately from ground water targets associated with fractured bedrock formations.

Several public water suppliers are located within the 4-mile distance categories. The Frederick County Department of Water and Wastewater Operations and Maintenance provides water to residents located north and west of Area B and serves the following communities: Braddock Heights, Fountaindale, Cloverdale, and White Rock. Frederick County uses three supply systems: Cloverhill III, Fountaindale, and White Rock. Cloverhill III serves a total of 886 persons from two wells located within a 1- to 2-mile radius and north of Area B. The two wells are completed in the New Oxford Formation, a karst aquifer. White Rock serves a total population of 248 from one well located within a 3- to 4-mile radius of Area B. The well is completed in the Harpers Formation, a non-karst aquifer (Ref. 15; Ref. 19; and Ref. 28). The populations served by Cloverhill III do not need to be apportioned to each well because the wells are located in the same target distance categories. The population for each well is summed and a distance-weighed value is obtained from Table 3-12, Reference 1 (Ref. 1, Section 3.3.2).

The Frederick County Fountaindale system serves a total population of 2,565 from five wells located within a 2- to 3-mile and 3- to 4-mile radius of Area B. The Fountaindale wells are located on the west side of the Catoctin Mountain and are completed in the Catoctin Metabasalt. Because the Catoctin Mountain is a barrier to ground water from the east to the west side of the mountain, these wells are not evaluated as potentially contaminated (Ref. 15; Ref.19; and Ref. 28).

The Table 16 summarizes the Frederick County wells, including well formations, locations, and population served. The well locations are shown on Reference 19.

TABLE 16
FREDERICK COUNTY SUPPLY WELLS

Target Distance Category (miles)	Well Identification	Service Area	Formation	Other Than Karst Pop.	Karst Pop.	References
1 to 2	FR-81-5372	Cloverhill III	New Oxford (Karst)	0	443	12, 15, 17, 19, 28
	FR-81-4199	Cloverhill III	New Oxford (Karst)	0	443	12, 15, 17, 19, 28
3 to 4	FR-01-8451	White Rock	Harpers	248	0	12, 15, 17, 19, 28

Notes:
Pop. = Population

The City of Frederick supplies water to all residents within the city's boundaries from a surface water intake on the Monocacy River outside the influence of Area B (Ref. 16; Ref. 17).

Three mobile home parks (MHP), Polings Mobile Home Estates, the Gilberts MHP, and the Spring View MHP, maintain public drinking water wells within a 2- to 3-mile radius of Area B. The MHP ground water wells draw from the Loudoun (non-karst) and New Oxford (karst) Formations. The Loudoun Formation well serves 80 persons and the New Oxford Formation serves 145 persons (Ref. 12; Ref. 18; Ref.19; Ref. 34; Ref. 45). Because the wells are located within the same target distance limit (2 to 3 mile), the population served for each well is not determined (Ref. 1, Section 3.3.2). The population for each well is summed and a dilution-weighed value is obtained from Table 3-12, Reference 1.

The town of Middletown in Frederick County is located west of the Catoctin Mountain and obtains drinking water from wells and springs located on the west side of the Catoctin Mountain. Because the wells are located west of the Catoctin Mountain, the population served by the wells and springs are not evaluated as potentially contaminated (Ref. 19; Ref. 43).

The areas outside of Frederick County and City of Frederick water distribution areas rely on private domestic wells. Available databases (Reference 27), the Maryland Department of Environmental Protection, and the topographic map for the target distance categories were used to identify the location of these residential wells. Reference 27 identifies drinking water wells using data from the United States Ground-Water Sites Inventory (GWSI) database. The database contains more than 850,000 records of wells, springs, test holes, tunnels, drains, and excavations in United States (Ref. 27, p. 1401; Ref. 38, pp. 1 and 2). The data from GWSI includes well location, well construction, ground-water, level, geohydrology, aquifer hydraulic, owner, and other data (Ref. 38, p.

2). A report generated from this database was used to identify private wells within a 4 mile radius of Area B (Ref. 27, p. 1401). The database identifies wells and the distance between the well and the latitude and longitude that is entered into the program. The latitude and longitude entered into the program was 39.4344 and 77.4468, respectively. The latitude and longitude were measured from the southwestern corner of the building centrally located in Area B (See Reference 42). The database provides the direction from the latitude and longitude at which the well is located. The distance of the well and the direction were used to determine what formation the well was completed in using Reference 12. Also, the relative locations of the wells were checked on Reference 19 to determine if public water supplies were available in the area.

The information collected from the database was used in conjunction with Reference 19. The public water distribution areas are outlined in Reference 19. Houses outside of the public water distribution area have private wells. A house count was conducted on Reference 19. Homes outside the public water distribution area were counted to derive the number of homes with a private well. Homes within the 4 mile target distance limit but west of the Catoctin Mountain eastern 700 ft msl elevation were not included in that number. That number of estimated homes with private wells is summarized in Table 17.

Although all formations within the study area are considered hydraulically connected, drinking water wells drawing from karst aquifers are evaluated separately because wells completed in karst aquifers are at a greater risk of contamination than those completed in other aquifers. According to the geologic map for this area, wells located northeast and southeast of the facility are completed within the Frederick and New Oxford Formations (karst aquifers) and wells northwest and southwest of the facility are completed in other aquifers. The other aquifers are summarized in Table 19. The karst regions in and surrounding Area B are documented in Section 3.0.1 of this documentation record. When conducting the house count on Reference 19, Reference 12 (geologic map) was reviewed to identify the formation the well is completed in. Reference 12 identifies the location of each formation that is present at the surface of the land. Residential wells are expected to be completed within the formation shown on Reference 12 because of the thickness of the formations (Ref. 12). Residential wells are generally drilled to a minimum depth (Ref. 9, p. 30). Table 17 summarizes domestic wells within each target distance category as well as the number of residential wells within karst and non-karst aquifers. The distance-weighted populations for karst aquifers are summarized in Table 18 and the distance-weighted populations for the other than karst aquifers are summarized in Table 19.

The closest potentially contaminated residential wells to Area B are located on the western boundary of Area B. These wells are shown in Reference 23, Exhibit 2-4, near the intersection of Shookstown and Bowers Road and on Reference 19 within the 0 to 0.25 distance ring.

The population served by each residential well is the average number of persons per household for Frederick County, Maryland or 2.72 persons (Ref. 20). Karst aquifers include aquifers within the Frederick and New Oxford Formations (Ref. 11).

Residential wells located along the southern boundary of Area B, on Shookstown Road, were closed because of contamination from Area B. The populations served by those wells are not used to evaluate potential contamination. The residents have been connected to the City of Frederick water distribution system (Ref. 16; Ref. 24; Ref. 26).

TABLE 17
DOMESTIC WELLS WITHIN 4-MILE RADIUS

Distance Category (miles)	Total Number of Domestic Wells Based on House Count	Formations	Non-Karst Population*	Karst Population*	Reference
0-0.25	21	Colluvium (karst characteristics)	0	57 (21 x 2.72)	12; 19; 23 Exhibits 2-4 and 4-3; 32, Exhibit 2-1
0.25-0.50	53	Antietam	144 (53 x 2.72)	0	12; 19; 27
0.50-1.0	176	New Oxford Antietam and Colluvium	479 (176 x 2.72)	0	12; 19; 27
1.0-2.0	295	New Oxford Colluvium, Antietam, Harpers, Manassas, Leesburg, Balls Bluff Siltstone, Antietam, and Poolesville	753 (2.72 x 277)	49 (2.72 x 18)	12; 19; 27
2.0-3.0	349	Frederick/New Oxford Antietam, Harpers, Colluvium, Owens Creek, Maryland Heights Manassas, Leesburg, Balls Bluff Siltstone, and Poolesville	435 (2.72 x 160)	514 (2.72 x 189)	12; 19; 27
3.0-4.0	634	Frederick/New Oxford Antietam, Harpers, Colluvium, Owens Creek, Maryland Heights, Manassas, Leesburg, Balls Bluff Siltstone, and Poolesville	516 (2.72 x 190)	1,208 (2.72 x 444)	12; 19; 27

Note:
*The population was determined as follows: 2.72 (average number of persons per household) × number wells

The Tables 18 and 19 summarize all drinking water wells subject to potential contamination and the distance-weighted population values for karst and non-karst aquifers.

TABLE 18
KARST AQUIFER DISTANCE-WEIGHTED POPULATION VALUES

Distance Category (miles)	Drinking Water Population (Formation)	Distance-Weighted Population (Ref. 1, Table 3-12)	Reference
0 – 0.25	57 Domestic (Colluvium with karst characteristics)	53	12; 19; 23 Exhibits 2-4 and 4-3; 32, Exhibit 2-1
1.0-2.0	49 Domestic 886 Frederick County (New Oxford)	261	12; 15; 17; 19; 28
2.0-3.0	514 Domestic 145 MPH (New Oxford)	261	12; 19
3.0 – 4.0	1,208 Domestic	817	12; 19
Total		**1,392**	

Notes: MHP = Mobile Home Park

TABLE 19
NON-KARST AQUIFER DISTANCE-WEIGHTED POPULATION VALUES

Distance Category (miles)	Drinking Water Pop. (Formation)	Distance-Weighted Pop. (Ref. 1, Table 3-12)	Reference
0.25-0.50	144 domestic (Antietam)	102	12; 19; 32, Exhibit 2-1
0.50-1.0	479 domestic (Antietam and Colluvium)	167	12; 19; 27
1.0-2.0	753 domestic (Colluvium, Antietam, Harpers, Manassas, Leesburg, Balls B luff Siltstone, and Poolesville)	94	12; 19; 27
2.0-3.0	435 domestic (Antietam, Harpers, Colluvium, Owens Creek, Maryland Heights, Manassas, Leesburg, Balls Bluff Siltstone) 80 MHP (Loudoun)	68	12; 19; 27; 34; 45.
3.0-4.0	516 domestic (Antietam, Harpers, Colluvium, Owens Creek, Maryland Heights, Manassas, Leesburg, Balls Bluff Siltstone, Antietam, and Poolesville) 248 Frederick County (Harpers)	42	12; 15; 17; 19; 27; 28
Total		**473**	

Notes: MHP = Mobile Home Park

Calculations:
Sum of Distance-Weighed Population Values: 1,865 (1,392 + 473)
Sum of Distance-Weighted Population Values/10: 186.5

Potential Contamination factor Value: 186.5

3.3.3 RESOURCES

Farms located outside the public water distribution systems use ground water to irrigate crops greater than 5 acres in size. The types of crops include forage, corn for grain, soybeans, corn for silage, and wheat for grain (Ref. 40).

Resources Factor Value: 5

3.3.4 WELLHEAD PROTECTION AREAS

Sources of potential contamination on Area B do not lie within a wellhead protection area; however, a wellhead protection area is within the target distance limit. The wellhead protection areas include all locations where public water supply wells are located as shown on Reference 18. The Maryland wellhead protection program was approved by EPA in 1991 (Ref. 39). A wellhead protection area factor value of 5 is therefore assigned.

Wellhead Protection Area Factor Value: 5